



Study conducted by:

COMMONWEALTH BIOMONITORING  
8061 Windham Lake Drive  
Indianapolis, IN 46214  
317-297-7713

# ***INDIAN CREEK WATERSHED DIAGNOSTIC STUDY***

**A Lake and River Enhancement Project  
funded by the Indiana Department of Natural Resources  
Division of Soil Conservation  
Indianapolis IN**

**For the Soil and Water Conservation Districts of  
Pulaski, Fulton, Cass, and White Counties**

**Submitted: January 2003  
Revised: September 2003**

## **Table of Contents**

	<b>Page Number</b>
<b>Executive Summary</b>	<b>i</b>
<b>I. Introduction</b>	
<b>A. Background of the study</b>	<b>1</b>
<b>B. Steps necessary to make a watershed diagnosis</b>	<b>2</b>
<b>II. Identifying critical information</b>	
<b>A. What do we already know about the watershed?</b>	<b>3</b>
<b>B. Summary of available information</b>	<b>11</b>
<b>III. Collection of additional necessary information</b>	
<b>A. Erodible soils on steep slopes</b>	<b>12</b>
<b>B. Location of critical wetlands</b>	<b>13</b>
<b>C. Chemical and biological sampling</b>	<b>14</b>
<b>D. Nutrient loading based on a computer model</b>	<b>37</b>
<b>IV. Identification of problems</b>	<b>40</b>
<b>V. Proposed solutions</b>	<b>40</b>
<b>VI. Preliminary cost estimates</b>	<b>45</b>
<b>VII. Project constraints and remedies</b>	<b>46</b>
<b>VIII. Public participation</b>	<b>48</b>
<b>IX. References</b>	<b>49</b>

## Table of Contents (Continued)

### Page No.

### Figures

Fig. 1	The Tippecanoe River and Indian Creek Watersheds	1
Fig. 2	Indian Creek land uses	4
Fig. 3	Indian Creek watershed soil types	6
Fig. 4	Combined sewer overflows in the watershed	8
Fig. 5	Confined feeding operations	10
Fig. 6	Stream segments with high erosion potential	12
Fig. 7	Wetlands in the watershed	13
Fig. 8	Water and biological sampling sites	15
Fig. 9	Degrees of impairment in the watershed	32
Fig. 10	Habitat scores vs. biological index scores	33
Fig. 11	Watersheds targeted for water quality improvement	34
Fig. 12	Watersheds targeted for habitat improvement	34
Fig. 13	Watersheds affected by sediment	35
Fig. 14	Watersheds affected by nutrients	36
Fig. 15	Daily AQUATOX model results for nutrients	38
Fig. 16	Daily AQUATOX model results for biology & clarity	38
Fig. 17	AQUATOX model predictions for one year	39
Fig. 18	Potential site for a constructed wetland	41

### Tables

Table 1	Dry weather water chemistry results	19
Table 2	Wet weather water chemistry results	21
Table 3	Benthic data	24
Table 4	IBI metrics and scoring	28
Table 5	Sediment intolerant species at each site	35
Table 6	Summary of proposed BMPs	40
Table 7	Potential sites for erosion-control BMPs	42
Table 8	Potential sites for wetland restorations	44
Table 9	Potential project constraints	46

### Appendices

Appendix A.	Aquatox model summary
Appendix B.	Habitat evaluation breakdown
Appendix C.	Public meeting attendance
Appendix D.	Information handouts

## EXECUTIVE SUMMARY

The Pulaski, Cass, Fulton, and White County Soil and Water Conservation Districts received a grant from the Indiana Department of Natural Resources Division of Soil Conservation through the Indiana Lake and River Enhancement Program. The purpose of the grant was to assist the districts make a diagnosis of water quality problems in the Indian Creek watershed and propose solutions to fix the problems identified. To accomplish this, all available information on the watershed was assembled. Then new chemical and biological information was gathered. A computer model was used to predict ecological changes that may be expected to occur with changes in land use. Finally, the new information was used to identify problems in the watershed and work toward economical solutions.

Indian Creek is one of the largest tributaries of the pristine and biologically diverse Tippecanoe River in northwestern Indiana. Land use in the Indian Creek watershed is dominated by agriculture, but many small, natural wetlands are also present. The Indian Creek area is identified by U.S. EPA as having a high potential for nutrient, sediment, and pesticide runoff. Within the category of agriculture uses, livestock production is very important. There are 19 “confined feeding operations” with state permits in the watershed. The town of Royal Center is the only community large enough to be served by a centralized wastewater treatment system.

Water chemistry and biological samples were collected at eleven sites on Indian Creek and a “reference” site on nearby Twelve Mile Creek, which previous studies had shown to be in excellent condition. Nutrient values at most Indian Creek sites were low compared to many other Indiana streams in agricultural areas, even during wet weather. Other water quality measurements fell within ranges suitable for most forms of freshwater aquatic life. Water temperatures were relatively low at most sites, indicating a strong groundwater influence and the presence of numerous springs in the watershed. Chemically, the watershed is in relatively good condition.

*E.coli* bacteria, which represent the potential for health risk to swimmers, were present at concentrations exceeding Indiana water quality standards at most sites during both dry and wet weather. Concentrations were considerably higher during wet weather. The upper end of Grassy Creek had particularly high *E.coli* concentrations. The source of bacterial contamination is unknown.

Aquatic habitat at some sites was impaired by channelization and lack of stream bank vegetation. This was especially true within the Little Indian Creek sub-watershed. Very high water temperatures and nuisance algae blooms occurred there because of the lack of shading. In contrast, Grassy Creek and Indian Creek had relatively good habitat and a benthic macroinvertebrate community indicative of better biological conditions. Pollution-sensitive caddisfly and mayfly species such as *Brachycentrus*, *Ceratopsyche*, *Chimarra*, and *Isonychia* were common in many of these areas. The lower end of Indian Creek had a biological community similar to that of the best streams in Indiana.

Computer modeling showed that Indian Creek would respond almost immediately to a 50% reduction in nutrient and suspended solids loading. A 12-month simulation of nutrient concentrations, water clarity, and benthic macroinvertebrates using the model AQUATOX showed that nitrate, ammonia, and phosphorus would decline immediately. Water clarity would increase roughly 50% during the winter months and about 20% on an annual basis. The density and biomass of invertebrates in the stream would increase by about 10% within seven months after nutrient reductions occurred.

The upper reaches of the Grassy Creek and Indian Creek watersheds were identified as areas where water quality improvements could be made. BMPs to address nutrients were recommended for Grassy Creek. A potential site for a constructed wetland was identified in this sub-watershed. BMPs to address excessive sediments were recommended for Indian Creek. Several sites with high slopes near watercourses were identified in this sub-watershed. Estimated costs to reduce nutrient inputs in the watershed by 50% were about \$280,000.

The upper reaches of Little Indian Creek were identified as areas where aquatic habitat restorations could be made. Recommendations were made for areas where channel modifications for drainage improvement are planned. These include limiting cutting of trees to only one side of the stream, doing channelization projects in small portions during a year, and keeping existing riffles in place.

A public meeting was also held as part of the project on December 3, 2003 at Pioneer High School in Royal Center, Indiana. Forty-five people attended (a sign-up sheet is attached in the Appendix). The meeting explained the findings of the study and some of the possible outcomes. A project brochure was produced and is attached in the Appendix.

# INDIAN CREEK WATERSHED DIAGNOSTIC STUDY

## I. INTRODUCTION

### A. BACKGROUND OF THE STUDY

Indian Creek is one of the largest tributaries (watershed area of 111 square miles) of the Tippecanoe River in northwestern Indiana (Fig.1). The Pulaski, Cass, Fulton, and White County SWCDs received funding from the Indiana Lake and River Enhancement program of IDNR in December 2001 to conduct a Watershed Diagnostic Study to help identify water quality problems and solutions in the watershed.

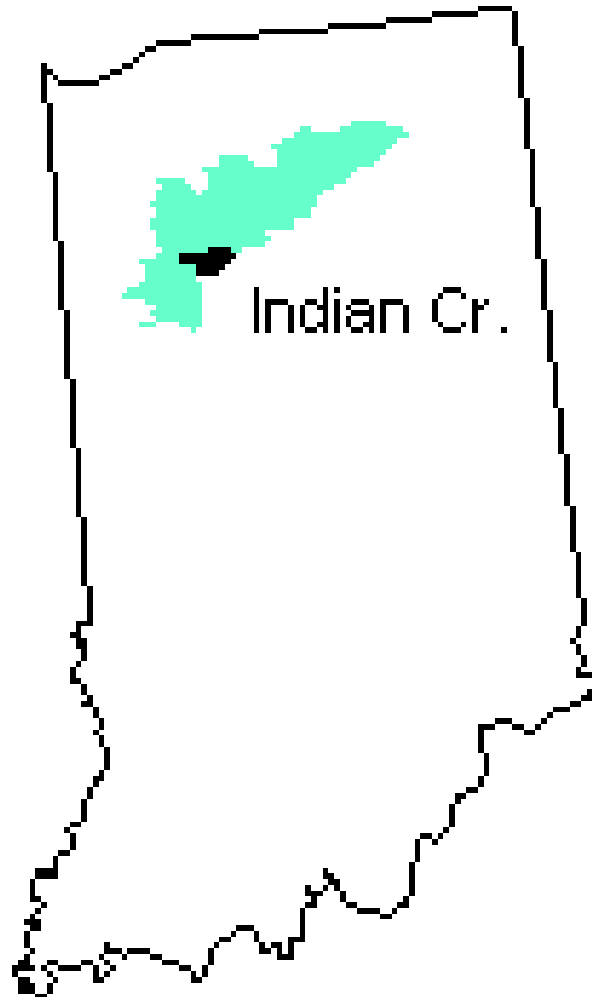


Figure 1. Tippecanoe River and Indian Creek Area

## B. STEPS NECESSARY TO FORMULATE A PLAN

1. Critical information gaps are identified.
2. Current conditions are described from available maps and land use information.
3. Water chemistry, biology, and habitat information are collected.
4. Computer models are used to predict changes expected to occur with potential changes in land use and management practices.
5. Specific problems in the watershed which could interfere with water quality are identified
6. Practical, economical solutions to the problems are identified
7. Specific sites for management are identified and their selections are justified
8. Potential project constraints (excessive costs, land uses, etc.) are identified. Available institutional resources already in place are assessed to determine their capacity for helping carry out the plan.
9. Potential sources of funding for future work necessary to carry out the plan are identified
10. An information handout explaining the plan (and made available at a public meeting) is presented

## II. IDENTIFYING CRITICAL INFORMATION: WHAT DO WE ALREADY KNOW ABOUT THE WATERSHED?

Indiana Geological Survey, 1995. Atlas of hydrogeologic terrains and settings of Indiana [20].

The Indian Creek watershed lies in a section of Indiana called the “Iroquois Morainal Region” by hydrogeologists. This area is characterized by low relief, with marshy till plains alternating with moderate to rugged glacial moraines (deposits of gravel and sand left behind by glaciers). The region has naturally poor surface drainage and a shallow water table.

History of Pulaski, Cass, Fulton, and White Counties. Local county historical society publications.

Settlers moved into the Indian Creek area in the early 1830's, after the land was purchased from the Miami Indians. They noted that the land was 50% forested and 50% prairie. The forests were mainly along the area's streams and were dominated by “scrubby oaks” in sandy soil. John Fletcher's family settled around Fletcher Lake in Fulton County in 1832. Andrew Kline's family found marshy conditions but good tillable soil in the Little Indian Creek watershed near Royal Center in 1834. The John Reed family began to make a living from lumber and a grist mill on Indian Creek near its confluence with the Tippecanoe River in 1837. The family observed numerous Indian mounds. The “Pulaski Pearl Divers” made an early living harvesting pearls from the freshwater mussels common in the Tippecanoe River in this area. According to local records, the building of drainage ditches to facilitate agriculture began around 1880.

USGS, 1980. Drainage atlas of Indiana [1].

Drainage areas of the subwatersheds:

Grassy Creek	35 sq. mi.
Indian Creek upstream from Grassy Creek	18 sq. mi.
Little Indian Creek upstream from Indian Creek	39 sq. mi.
Indian Creek at the confluence with Tippecanoe River	111 sq. mi.

Purdue University, Department of Agronomy. Agricultural statistics for 2000 [17].

Land use within Cass, Fulton, Pulaski, and White Counties (where the Indian Creek watershed is located) has the following breakdown:

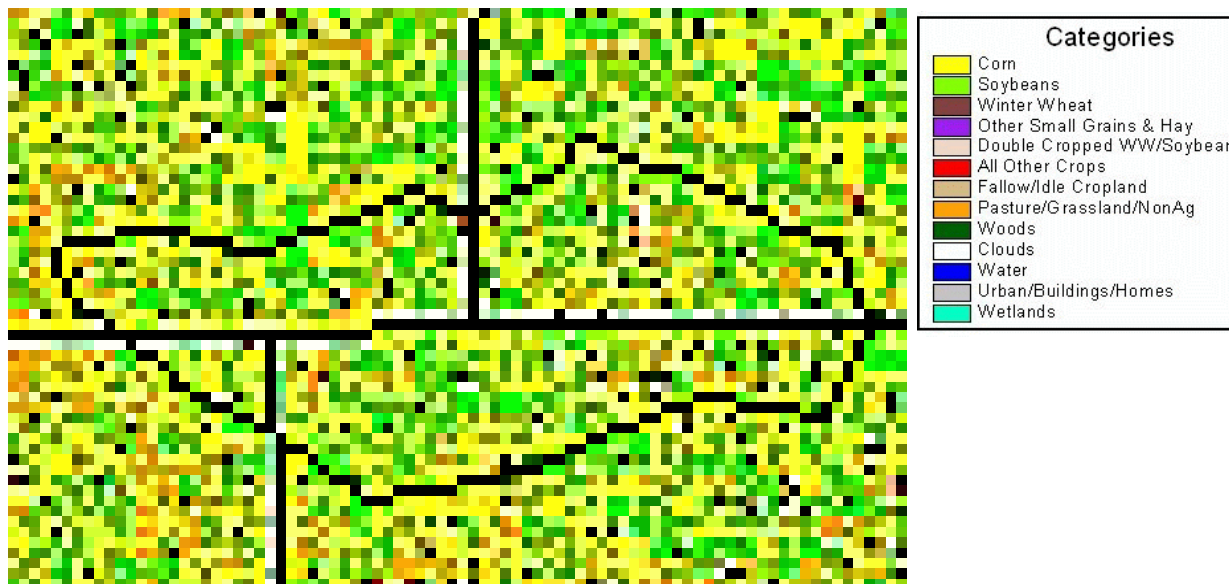
Agriculture: Corn	48%
Agriculture: Soybeans	42%
Pasture	5%
Woods	5%
Urban	<1%

A detailed map (generated by satellite imagery for the summer of 2001) showing land uses within the watershed is displayed in Fig. 2.

Livestock production for these counties is higher than the state average in most categories. This is especially true for hog production, where the county rankings are usually in the top 25%. There are no figures kept specifically for the Indian Creek watershed. However, if the county figures are representative of Indian Creek, the following numbers of livestock are estimated to be present in the watershed:

Cattle	2000
Hogs	11,000
Sheep	200

Fig. 2. Indian Creek land uses from satellite data.  
The Indiana Creek watershed is outlined in black.  
County lines are also outlined in black to aid interpretation



Indiana Lake Classification System and Management Plan, 1986 [12].

Fletcher Lake, in the headwaters of Grassy Creek, is the watershed's only natural lake with public access. The trophic status of Fletcher Lake was determined during the 1970s. The Trophic Index value was 45 (Class 2, eutrophic)

Indiana Department of Environmental Management, 1998. Indiana Lake Water Quality Update Data from SPEA [19].

The trophic status of Fletcher Lake was determined again in 1990 and 1998. The latest IDEM Trophic Index values were 25-34. This indicates a substantial improvement in water quality from earlier years.

Indiana Department of Environmental Management, Unified watershed assessment data, 1999 [21].

This information includes local data on residential septic system density, livestock density, and cropland pressure. The Indian Creek watershed has the following ratings (scale ranging from 1 low concern to 5 high concern):

Septic Tank Density	1 Indian Creek, 2 Little Indian Creek
Livestock Density	3 upper watershed, 4 lower watershed
Cropland Pressure	4 upper watershed, 5 lower watershed

The 11-digit HUC identification for this watershed is 05120106090

USGS, 1989. Statistical summary of streamflow data for Indiana. Report 89-62, Water Resources Division, Indianapolis IN [2].

Little Indian Creek at Royal Center - 1959-1973

Draining area = 35 square miles

Average flow = 29 cfs

Lowest flow = 0.5 cfs

Q7,10 = 0.8 cfs

Indian Creek at Thornhope

Drainage area = 57 square miles

Q7,10 = 8.4 cfs

These data for old stream gaging stations show that each stream has permanent flow but that Indian Creek has unusually high flow for its drainage area. A Q7,10 flow of less than 1 cfs would be more common. The higher "low flow" condition indicates the presence of high ground water inputs in the watershed.

Homoya et al., 1985. The natural regions of Indiana [3].

The Indian Creek watershed lies primarily in the “Kankakee Sand Section” of the “Grand Prairie” natural region of Indiana. This ecoregion is characterized by sandy soils, where white and black oaks and prairie species are the predominant natural vegetation. Wetlands in the area are characterized by a unique set of plants similar to those found in coastal plains of the United States. These include bladderwort, panic grass, nutrush, beak rush, yellow-eyed grass, flax, and bugleweed. Sand habitat animals such as ornate box turtle, bull snake, glass lizard, plains pocket gopher, and lark sparrow are found here.

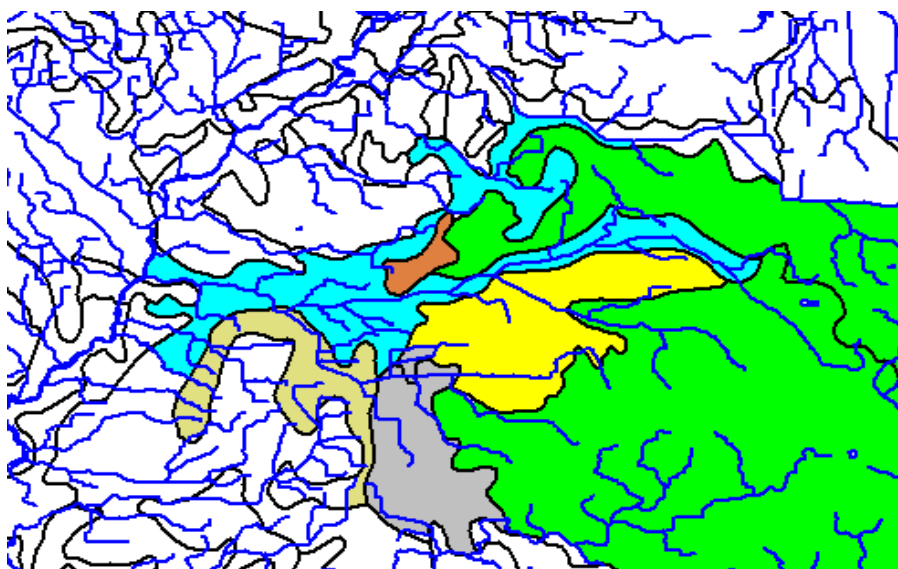
The upper part of the watershed is different, more similar to the “northern lakes” natural region where Indiana’s glacial lakes are found.

U.S. Department of Agriculture. Soil surveys of Fulton, Cass, Pulaski, and White Counties. Soil Conservation Service. Available in the NRCS Indiana office, Indianapolis, IN [13-16].

There are six primary soil types in the watershed. These are mapped in Figure 3 and described below:

Green = Riddles-Rensselaer-Crosier  
Yellow = Wawasee-Rensselaer-Crosier  
Blue = Maumee-Gilford-Rensselaer  
Light Brown = Gilford-Oakville  
Grey = Rush-Gilford-Sleeth  
Dark Brown = Plainfield-Chelsea

Fig. 3 Indian Creek soil types



Common characteristics of each soil type are:

Rensselaer	Very poorly drained. Loam and sand. Low slopes.
Gilford	Very poorly drained. Loam, sand and clay. Low slopes
Crosier	Somewhat poorly drained. Loamy. Low slopes.
Riddles	Well drained. Sandy loam. Low to high slopes.
Wawasee	Well drained. Sandy loam. Higher slopes.
Maumee	Very poorly drained. Loam and fine sand. Low slopes.
Oakville	Moderately well drained. Sand. Low slopes.
Rush	Well drained. Loess and loam. Low to moderate slopes.
Gilford	Very poorly drained. Loam, sand, and clay. Low slopes.
Sleeth	Somewhat poorly drained. Loess and loam. Low slopes.
Plainfield	Excessively well drained. Sandy. Low to high slopes.
Chelsea	Excessively well drained. Sandy. Higher slopes.

The soil types most prone to water erosion are Riddles and Wawasee. These have K values (a number indicative of the potential for soil to erode) that are greater than 0.3 and may be present on steep slopes.

The soil types least prone to water erosion are Oakville and Plainfield These have K values less than 0.2 and are usually present only on low slopes.

U.S. EPA, 1994. Fish community data for Indian Creek [18].

As part of a study of all streams in this area, fish were collected from Indian Creek at Highway 119 (at the lower end of the watershed) in 1994. Fish diversity was low (6 species) and the number of fish collected in a standardized sampling time was also low. The index of biotic integrity for this site was only 24 on a scale of 0 to 60 (poor biotic integrity).

Carney et al., 1993. Fish community data for Tippecanoe River [5].

As part of a study of fish in the Tippecanoe River, the authors made collections immediately upstream and downstream from Indian Creek. Forty-four species of fish were present in this 8-mile stretch of stream. This is a very high diversity, and includes rare species such as bigeye chub, ghost shiner, bluebreast darter, eastern sand darter, tippecanoe darter, and gilt darter.

Cummings, et al. 1987. Mussel community data for Tippecanoe River [6].

As part of a study of mussels in the Tippecanoe River, the authors made collections upstream and downstream from Indian Creek. Twenty-six species of mussels were present in this stretch of river. This is a very high diversity and includes rare species such as *Obovaria subrotunda*, *Plethobasus cyphus*, *Ptychobranhus fasciolaris*, and *Quadrula cylindrica*.

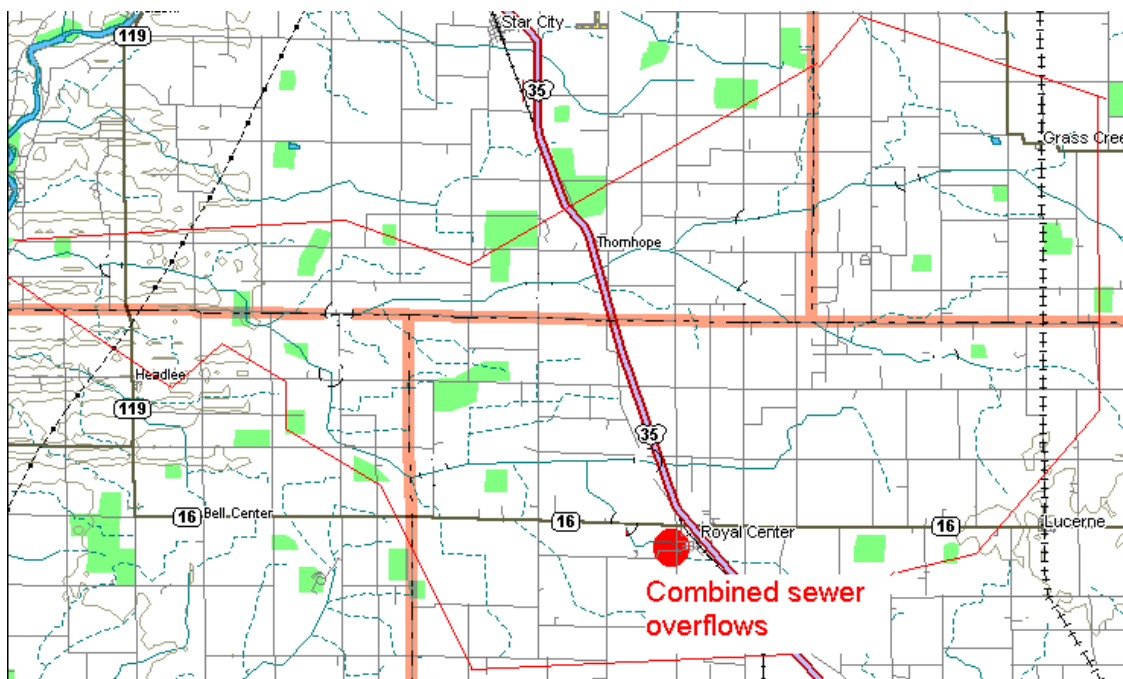
Indiana Natural Resources Commission, 1993. Outstanding rivers list for Indiana [22].

This list was compiled and incorporated into Indiana regulations governing utility line crossings and logjam removals on streams with particular environmental or aesthetic interest. The Tippecanoe River in Pulaski County is designated as an “outstanding Indiana river” for three reasons: (1) it was identified by the National Park Service as qualified for inclusion in the National Wild and Scenic Rivers System, (2) it has state-designated canoe routes, and (3) it flows through a state park (Tippecanoe River State Park).

Water Quality Monitoring Data - Royal Center Wastewater Treatment Plant. 2001 [23].

There is one permitted wastewater discharge in the Indian Creek watershed. The Royal Center Wastewater Treatment Plant discharges an average of 0.2 mgd of treated wastewater to Fredricks Ditch in the Little Indian Creek subwatershed. Self-monitoring data show that dissolved oxygen, pH, suspended solids, chlorine and ammonia in the effluent consistently meet water quality standards for aquatic life. However, the treatment plant becomes overloaded during rain events and combined sewer overflows frequently occur at two sites. The potential for water quality problems is high when this occurs. The location of CSOs in the watershed is shown in Fig. 4.

Fig. 4. Combined sewer overflows (CSOs) in the watershed)



Hoosier River Watch Data. 2001 [24].

Hoosier River Watch is an organization sponsored by the Indiana Department of Natural Resources to oversee volunteer water quality monitoring efforts. There is one active group in the watershed. The Pioneer High School Science Club monitors water quality in Fredricks Ditch on a regular basis. Data collected by this group in 2001 indicated that the biological community is in "fair" condition. Dissolved oxygen and pH were always within normal ranges, but nutrient values are often very high (phosphorus greater than 0.5 mg/l and nitrate greater than 10 mg/l. Their monitoring site is near the Royal Center, shown by the red dot in Fig. 4.

IDNR Natural Heritage Data. Division of Nature Preserves, 2002.

The Division of Nature Preserves maintains a database of endangered, threatened, and rare species and natural areas. A list of these natural resources which are known to exist in the Indian Creek area is shown in the appendix. Most of the citations in the list are fish and mussels from the Tippecanoe River. Rare species known to be present within the Indian Creek watershed are:

American Badger (*Taxidea taxus*) - state endangered  
Straw Sedge (*Carex straminea*) - state threatened  
Twp 7, 4 miles west of Royal Center  
Western silvery aster (*Aster sericeus*) - state rare  
Twp 28, north of Thornhope

Uncommon species known to be present in nearby watersheds include:

Blue-spotted salamander (*Ambystoma laterale*) - state special concern  
Northern leopard frog (*Rana pipiens*) - state special concern  
Ornate box turtle (*Terrapene ornata*) - state endangered  
Small purple-fringe orchis (*Platanthera psycodes*) - state rare  
Rough rattlesnake-root (*Prenanthes aspera*) - state rare

U.S.EPA Index of Watershed Indicators. 2002 [25].

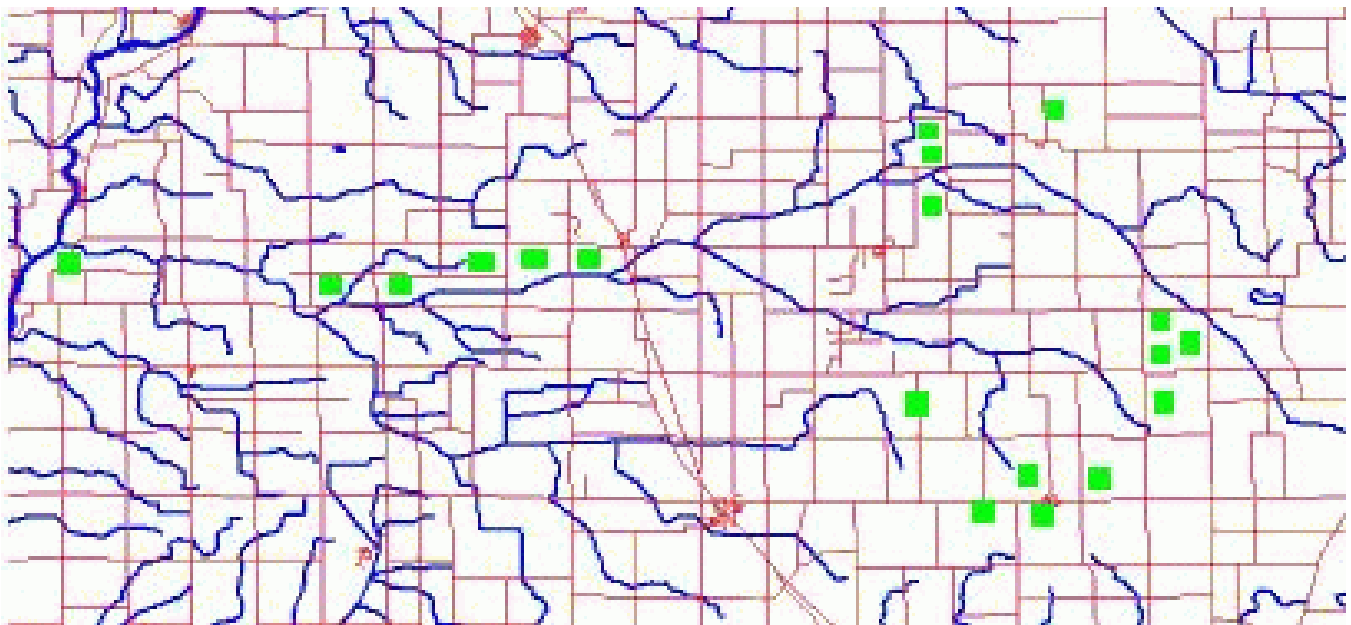
EPA has taken state information from various environmental regulatory agencies and prepared maps of “watershed indicators” for various potential sources of degraded water quality. The data for the Indian Creek area show that the watershed has high potential rates of:

- Soil Permeability
- Nutrient Export
- Pesticide Export
- Nitrogen Export
- Sediment Export

IDEM, Office of Land Quality, 2001, List of confined feeding operations [26].

There are 19 confined feeding operations in the Indian Creek watershed. The location of these sites in the watershed are shown in the map in Figure 5.

Fig. 5. Confined feeding operations in the Indian Creek watershed.



## B. SUMMARY OF AVAILABLE INFORMATION

Total drainage area of Indian Creek is 111 square miles. The three primary subwatersheds are Indian Creek, Little Indian Creek, and Grassy Creek. Upper Indian Creek has a steady flow of water, even during very dry periods, indicating that groundwater contributions are probably high. Flooding is not common in the watershed and flood risk occurs only in the lowest part of the Indian Creek watershed, along old oxbows where the river has been channelized.

Almost all of the streams in the Indian Creek watershed have been artificially straightened. However, none are presently classified as “legal drains.” About 90% of the watershed is devoted to row-crop agriculture, with 5% in woods and 5% in pasture. Livestock production, especially for hogs, is higher than the state average. There are 19 confined feeding operations in the watershed.

There are only three rare or threatened species known from the Indian Creek watershed, although several additional species are known from nearby watersheds. The Tippecanoe River immediately downstream from Indian Creek is one of Indiana’s best aquatic resources, supporting numerous rare fish and mussel species. It has been named one of Indiana’s Outstanding Rivers, making it eligible for special consideration in certain environmental regulations.

In contrast to the Tippecanoe River, the aquatic community of Indian Creek is not very diverse and composed of a few relatively common and tolerant fish species.

Indian Creek has high vulnerability for nutrient, pesticide and sediment export. It is intensively farmed. Some soils in the watershed have a moderate to high potential erosion rate. There is a low density of septic tanks, a medium to high density of livestock, and a high density of “cropland pressure.”

There is one wastewater discharger in the watershed. The Town of Royal Center has the potential to cause water quality problems due to two combined sewer overflows which discharge partially treated sanitary wastes to Fredricks Ditch in the Little Indian Creek subwatershed after rain events.

There are two active water quality monitoring groups in the watershed. The Pioneer High School Science Club in Royal Center monitors water quality in Fredricks Ditch. The Nature Conservancy local office in Winamac coordinates biological monitoring in Tippecanoe River.

There is one public lake in the watershed. Fletcher Lake in Fulton County is a natural glacial lake with a surface area of 45 acres and a maximum depth of 60 feet. It is eutrophic (has relatively high nutrients and algae), but its water quality seems to have improved rather dramatically over the past 25 years.

### III. COLLECTION OF ADDITIONAL NECESSARY INFORMATION

WHAT ADDITIONAL INFORMATION DO WE NEED TO MAKE GOOD DECISIONS ABOUT WATER QUALITY MANAGEMENT IN THIS WATERSHED?

#### A. WATERCOURSES ON STEEP SLOPES

Portions of streams which flow through areas of steep slopes on soils which are vulnerable to erosion are most likely to contribute to excessive sediment loading. Therefore, it is important to identify areas within a watershed on steep slopes. Digital elevation maps (DEMs) produced by the U.S. Geological Survey are useful for this type of analysis. A DEM for the Indian Creek watershed, with stream segments flowing directly through areas with slopes greater than 10% highlighted in black, is shown in Fig. 6.

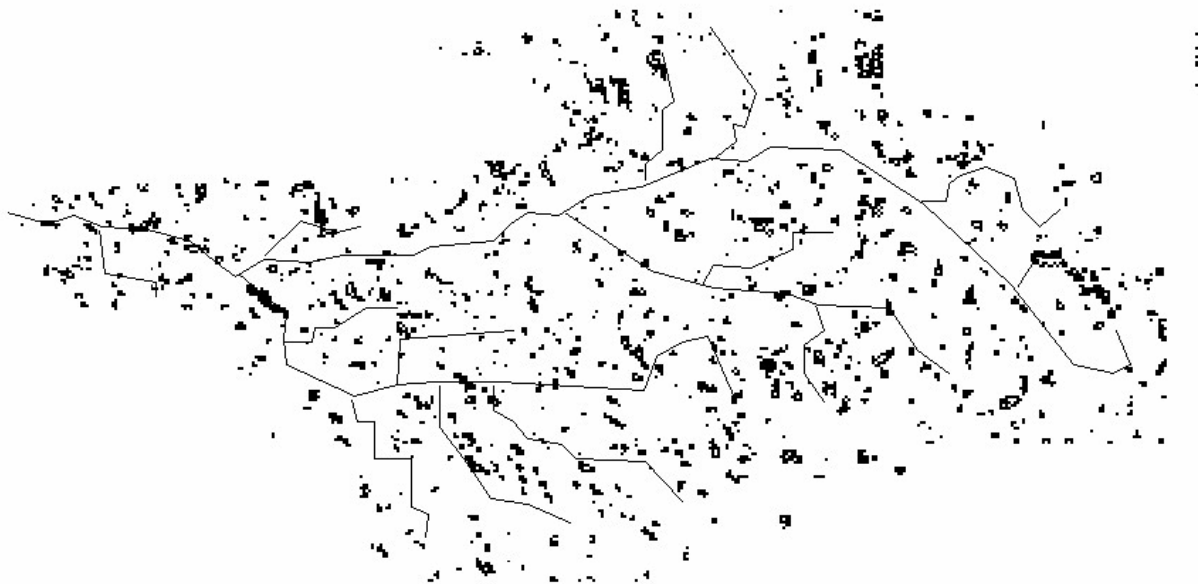
Fig. 6. Stream segments with high erosion potential



## B. WETLANDS

There are numerous wetlands in the watershed. A map of wetlands based on the National Wetland Inventory maps is shown in Figure 6. Most of these are “palustrine” (shallow, freshwater, not flowing) with a high potential for sediment and nutrient filtration. Some wetlands in this map have been severely drained for agriculture but could be restored at relatively low cost to assist with sediment and nutrient control. This option is discussed in more detail in Section V.

Fig. 7. Location of wetlands in the Indian Creek watershed



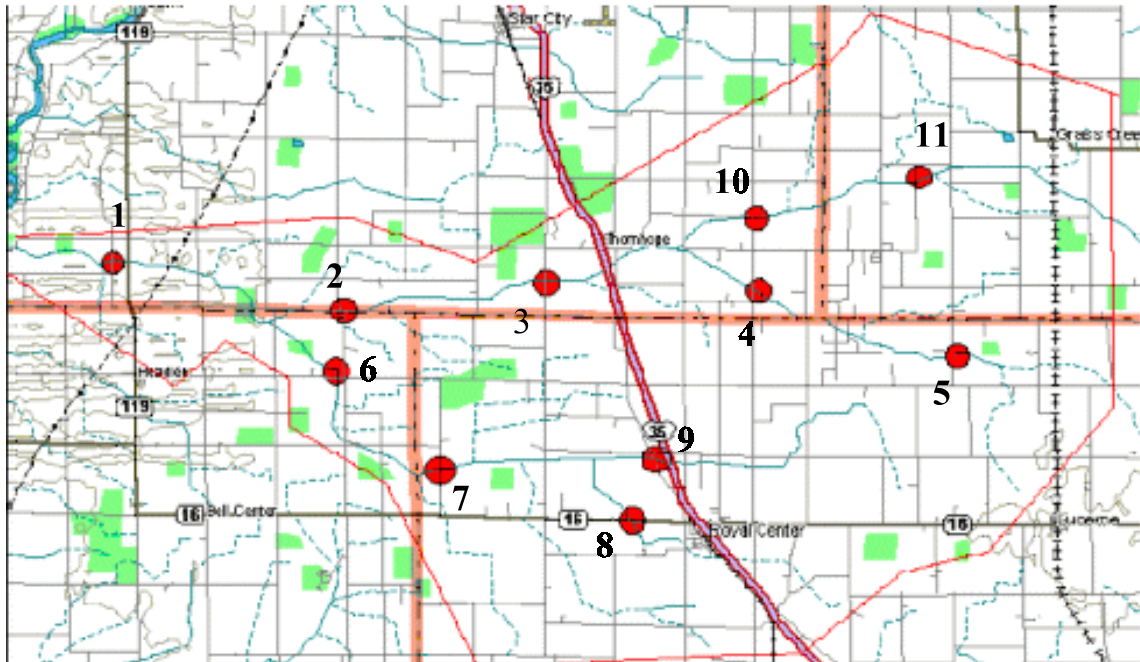
### C. CHEMICAL AND BIOLOGICAL SAMPLING

Chemical and biological sampling within the watershed was conducted to provide a diagnosis of what kinds of water quality problems exist and how severe they are.

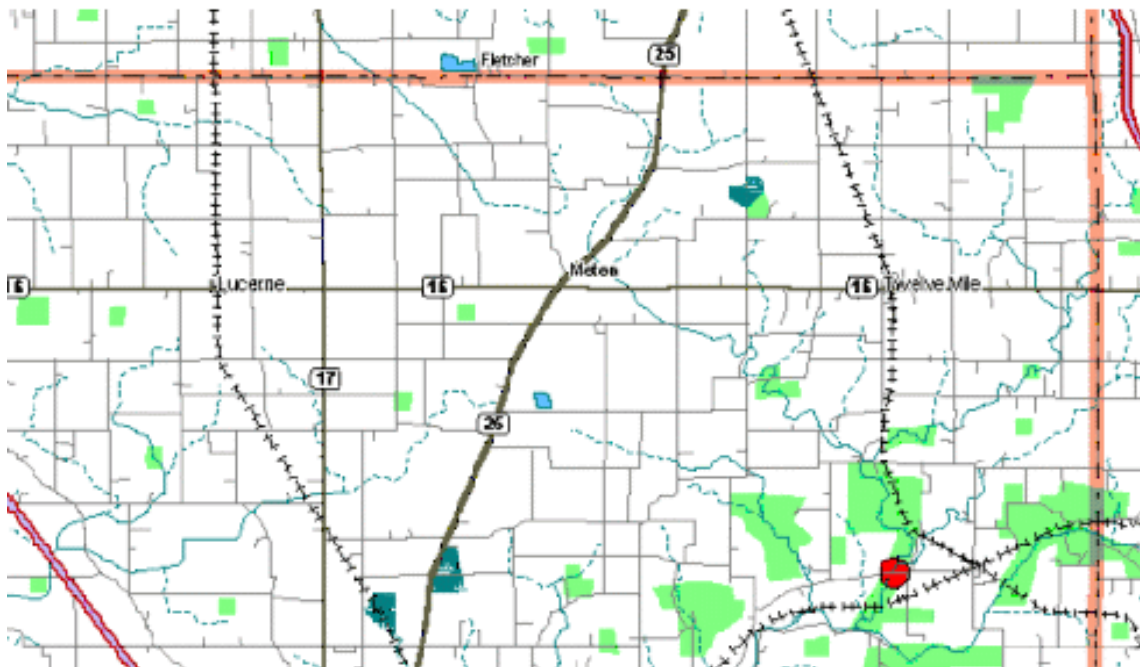
Twelve sampling sites were chosen for this study, including a nearby “reference site” known to have relatively good water quality, aquatic habitat, and fish communities. The reference site is used to provide a basis for comparison. Watershed areas of each site [18] and their locations are shown below:

Site	Description	Drainage Area	Latitude	Longitude
Site 1	Indian Creek at Hwy 119	192 km <sup>2</sup> (75 mi <sup>2</sup> )	40.55.315	86.39.648
Site 2	Indian Creek at Baseline Rd.	115 km <sup>2</sup> (45 mi <sup>2</sup> )	40.54.664	86.36.053
Site 3	Indian Creek at CR 300 E	105 km <sup>2</sup> (41 mi <sup>2</sup> )	40.55.057	86.32.713
Site 4	Indian Creek at CR 600 E	31 km <sup>2</sup> (12 mi <sup>2</sup> )	40.54.949	86.29.267
Site 5	Indian Creek at CR 1050 W	20 km <sup>2</sup> (8 mi <sup>2</sup> )	40.54.102	86.25.954
Site 6	Little Indian Cr @ CR 1000 N	59 km <sup>2</sup> (23 mi <sup>2</sup> )	40.53.849	86.36.183
Site 7	Little Indian Cr @ CR 1050 W	44 km <sup>2</sup> (17 mi <sup>2</sup> )	40.52.690	86.34.478
Site 8	Frederick Ditch @ Hwy 16	8 km <sup>2</sup> (3 mi <sup>2</sup> )	40.52.026	86.31.241
Site 9	Little Indian Cr @ Hwy 35	13 km <sup>2</sup> (5 mi <sup>2</sup> )	40.52.815	86.30.912
Site 10	Grassy Creek at CR 600 E	44 km <sup>2</sup> (17 mi <sup>2</sup> )	40.55.863	86.29.261
Site 11	Grassy Creek at CR 300 W	29 km <sup>2</sup> (11 mi <sup>2</sup> )	40.56.321	86.26.544
Reference Site				
Site 12	Twelve Mile Cr at CR 450 N	115 km <sup>2</sup> (45 mi <sup>2</sup> )	40.49.839	86.13.900

Figure 8  
Study Sites  
Indian Creek Watershed



Reference Site (Twelve Mile Creek Watershed)



## METHODS

Because they are considered to be more sensitive to local conditions and respond relatively rapidly to environmental change, benthic (bottom-dwelling) organisms were used to document the biological condition of each stream. The U.S. Environmental Protection Agency (EPA) has recently developed a "rapid bioassessment" protocol [10] which has been shown to produce highly reproducible results that accurately reflect changes in water quality. We used EPA's Protocol III to conduct this study. Protocol III requires a standardized collection technique, a standardized subsampling technique, and identification of at least 100 animals from each site to the genus or species level from both "study sites" and a "reference site." CPOM (Coarse Particulate Organic Matter) samples were collected and analyzed to determine the percentage of shredder organisms.

### Reference Site

The aquatic community of a reference site is compared to that of each study site to determine how much impact has occurred. The reference site should be in the same "ecoregion" as the study sites and be approximately the same size. It should be as pristine as possible, representing the best conditions possible for that area.

A previous study of the aquatic community of the Eel River watershed [8] found that Twelve Mile Creek in Cass County had one of the best fish communities and habitat values in the area. This was confirmed by a later study of the macroinvertebrates [7]. Since this stream is in the same geographic area as Indian Creek and is roughly the same size, Twelve Mile Creek makes an ideal reference stream.

### Habitat Analysis

Habitat analysis was conducted according to Ohio EPA methods [21]. In this technique, various characteristics of a stream and its watershed are assigned numeric values. All assigned values are added together to obtain a "Qualitative Habitat Evaluation Index." The highest value possible with this habitat assessment technique is 100.

## Water Chemistry

Water chemistry measurements were made at each study site on the same day that macroinvertebrate samples were collected. Dissolved oxygen was measured by the membrane electrode method. The pH measurements were made with a Cole-Parmer pH probe. Conductivity was measured with a Hanna Instruments meter. Temperature was measured with a mercury thermometer. All instruments were calibrated in the field prior to measurements. Samples for nutrient and bacteria analysis were collected as grabs and returned to the lab for analysis.

## Macroinvertebrate Sample Collection

Benthic samples in this study were collected using Hester-Dendy artificial substrates placed where current speed was 20-30 cm/sec. Artificial substrates were used because riffle habitat was missing from several study sites. The samplers were set in place on July 16-17 and retrieved August 20, 2002. When retrieved, the samplers were disassembled and scraped free of all attached benthos. The samples were preserved in the field with 70% isopropanol and returned to the lab for analysis.

## Laboratory Analysis

In the laboratory, a 100 organism subsample was prepared from each site by evenly distributing the whole sample in a white, gridded pan. Grids were randomly selected and all organisms within grids were removed until 100 organisms had been selected from the entire sample.

Each animal was identified to the lowest practical taxon (usually genus or species). As each new taxon was identified a representative specimen was preserved as a "voucher." All voucher specimens have been deposited in the Purdue University Department of Entomology collection.

## RESULTS

### Aquatic Habitat Analysis

When the Ohio EPA habitat scoring technique was used, the following aquatic habitat values were obtained for each site in the study:

	Score	% of Reference
Indian Creek (Site 1)	73	95
Indian Creek (Site 2)	53	69
Indian Creek (Site 3)	54	70
Indian Creek (Site 4)	60	78
Indian Creek (Site 5)	47	61
Little Indian Creek (Site 6)	57	74
Little Indian Creek (Site 7)	40	52
Frederick Ditch (Site 8)	36	47
Little Indian Creek (Site 9)	39	51
Grassy Creek (Site 10)	62	81
Grassy Creek (Site 11)	53	69
Twelve Mile Creek (Site 12)	77	100

The maximum value obtainable by this scoring technique is 100, with higher values indicating better aquatic habitat. Sites with lower habitat values normally have lower biotic index values as well.

The scores indicate that the lowest aquatic habitat values in this study were at Sites 7-9 in the Little Indian Creek watershed. Habitat at these sites was hampered by a paucity of stable bottom substrate and instream cover, by a lack of any riparian buffer zone, and by channelization.

### Water Quality Measurements

Water chemistry results collected during dry weather are shown in Table 1. Data collected in wet weather are shown in Table 2.

Table 1. Dry Weather  
WATER QUALITY MEASUREMENTS  
May 24, 2002

	D.O. mg/l	pH SU	Cond. uS	Temp. (C)
Site 1 (Indian Creek) Time = 1:10 p.m.	9.6	8.0	410	13.9
Site 2 (Indian Creek) Time = 12:50 p.m.	8.8	7.7	390	13.1
Site 3 (Indian Creek) Time = 1:30 p.m.	10.2	7.7	410	13.5
Site 4 (Indian Creek) Time = 2:30 p.m.	9.4	8.8	390	14.1
Site 5 (Indian Creek) Time = 3:30 p.m.	9.7	7.8	450	16.2
Site 6 (Little Indian Creek) Time = 12:30 p.m.	9.5	7.7	420	13.6
Site 7 (Little Indian Creek) Time = 12:15 p.m.	9.2	7.6	390	13.6
Site 8 (Frederick Ditch) Time = 11:45 a.m.	12.4	8.3	450	13.7
Site 9 (Little Indian Creek) Time = 2:10 p.m.	12.1	7.1	390	16.5
Site 10 (Grassy Creek) Time = 2:40 p.m.	9.6	7.8	430	17.8
Site 11 (Grassy Creek) Time = 3:15 p.m.	9.2	7.6	420	15.0
Site 12 (Twelve Mile Creek) Time = 10:50 a.m.	10.1	7.2	400	13.6

D.O. = Dissolved Oxygen

Cond. = Conductivity

Temp. = Temperature in Degrees Centigrade

Table 1 (continued). Dry weather water quality measurements. May 24, 2002

Site Name	Alk mg/L	Hard mg/L	NH3 mg/L	NO2 ug/L	NO3 mg/L	TDS mg/L	OrthP mg/l	TKN mg/l	Coliforms Ecoli All /100 ml		TSS mg/l	TotP mg/l	ChlA ug/l	Turb NTU
Site 1 Indian Cr. Hwy 119	108	330	<0.1	<0.01	2.9	517	0.03	1.05	44	96	5	0.04	86	1.9
Site 2 Indian Cr. Base Line	116	396	<0.1	<0.01	2.6	473	0.04	1.15	108	309	4	0.06	82	1.3
Site 3 Indian Cr. 300E	120	374	<0.1	<0.01	2.8	500	0.04	1.3	211	1057	7	0.14	90	1.0
Site 4 Indian Cr. 600E	136	374	<0.1	<0.01	3.0	490	0.03	1.05	53	490	6	0.11	78	0.1
Site 5 Indian Cr. 300W	136	366	<0.1	<0.01	2.5	507	0.02	1.2	376	1138	1	0.08	84	1.9
Site 6 Little Indian 1000N	120	388	<0.1	<0.01	2.8	503	0.03	1.3	154	690	12	0.12	68	1.7
Site 7 Little Indian 1050W	128	286	<0.1	<0.01	3.3	527	0.04	1.8	45	247	7	0.05	77	0.8
Site 8 Fredrick Ditch	124	350	<0.1	<0.01	2.3	587	0.06	0.55	24	98	1	0.14	59	0.2
Site 9 Little Indian Hwy 35	112	286	<0.1	<0.01	3.4	490	0.02	0.65	182	325	3	0.16	72	0.1
Site 10 Grassy Cr. 600 E	120	343	<0.1	<0.01	1.5	457	0.04	1.5	864	1600	10	0.11	98	2.0
Site 11 Grassy Cr. 300 W	128	294	<0.1	<0.01	3.2	473	0.04	2.25	527	915	8	0.1	114	1.2
Site 12 Twelvemile Cr.	116	352	<0.1	<0.01	2.5	447	0.03	1.3	0	0	3	0.07		
Indian Cr. 300W (Duplicate)	112	400	<0.1	<0.01	3.3	470	0.04	0.95	465	1069		0.09		

Table 2. Wet Weather  
WATER QUALITY MEASUREMENTS  
July 30, 2002

	D.O. mg/l	pH SU	Cond. uS	Temp. (C)
Site 1 (Indian Creek) Time = 2:00 p.m.	8.9	8.1	586	24.4
Site 2 (Indian Creek) Time = 1:30 p.m.	8.5	7.9	570	23.9
Site 4 (Indian Creek) Time = 12:30 p.m.	8.6	7.8	580	23.1
Site 6 (Little Indian Creek) Time = 5:05 p.m.	8.3	7.8	633	25.0
Site 7 (Little Indian Creek) Time = 2:30 p.m.	9.2	8.0	680	31.7
Site 8 (Frederick Ditch) Time = 3:00 p.m.	9.1	7.6	920	28.9
Site 10 (Grassy Creek) Time = 12:00 p.m.	8.3	7.8	615	24.7

D.O. = Dissolved Oxygen

Cond. = Conductivity

Temp. = Temperature in Degrees Centigrade

Table 2 (continued). Wet Weather Water Quality Measurements July 30, 2002

Site Name	Alk mg/L	Hard mg/L	NH3 mg/L	NO2 ug/L	NO3 mg/L	TDS mg/L	OrthP mg/l	TKN mg/l	E.coli MPN/100 ml	TSS mg/l	TotP mg/l	ChlA ug/l	Turb NTU
Site 1 Indian Cr. Hwy 119	172	343	0.3	<0.01	1.6	383	0.05	0.48	930	8	0.14	413	0.9
Site 2 Indian Cr. Base Line	164	315	0.3	<0.01	1.5	383	0.05	0.53	825	13	0.12	336	1.3
Site 4 Indian Cr. 600E	168	273	0.3	<0.01	1.9	406	0.05	0.71	1770	6	0.18	426	2.2
Site 6 Little Indian 1000N	172	301	0.6	<0.01	2.4	439	0.07	0.71	180	6	0.13	278	0.2
Site 7 Little Indian 1050W	180	322	0.6	<0.01	1.8	439	0.04	1.0	630	64	0.21	2240	4.7
Site 8 Frederick Ditch	212	385	0.6	<0.01	3.0	541	0.20	1.0	720	23	0.62	413	8.4
Site 10 Grassy Cr. 600 E	160	364	0.3	<0.01	1.7	399	0.12	1.0	2190	8	0.21	571	2.2
Indian Cr. 600E (Duplicate)				<0.01		416	0.04						
Frederick Ditch (Duplicate)			0.7		3.6		0.20						
Indian Creek Base Line (Dupl)										7			

QUALITY ASSURANCE DUPLICATE RESULTS  
Indian Creek (CR 600 E)

Sample Date - 8/20/02

	Actual Data	
	Sample 1	Sample 2
Total Genera	5	7
EPT Genera	2	3
Scrapers/Filterers	0.2	0.1
% Dominant Taxon	18	34
EPT/Chironomids	0.5	0.8
Community Loss Index	1.8	1.3
Hilsenhoff Biotic Index	6.4	6.6
% Shredders	0	1

	IBI Scores	
	Sample 1	Sample 2
Total Genera	0	2
EPT Genera	0	0
Scrapers/Filterers	0	0
% Dominant Taxon	6	2
EPT/Chironomids	6	6
Community Loss Index	2	4
Hilsenhoff Biotic Index	4	4
% Shredders	3	6
Total Score	21	24

Mean Site Score = 22.5

Each duplicate is within 10% of the mean

Both scores indicate "moderate impairment"

The quality assurance duplicates provided strong evidence that the bioassessment technique produced reproducible data during this sampling period.

Table 3.  
Rapid Bioassessment Results - Indian Creek Watershed  
August 2002

	Site #					
	1	2	3	4	5	6
Chironomidae (Midges)	40	10	34	58	10	30
Empididae (Danceflies)					1	
Simuliidae (Blackflies)	2					
Tipulidae (Craneflies)						
Tipula sp.		1				
Antocha sp.			1			
Ephemeroptera (Mayflies)						
Heptagenia sp.						
Baetis brunneicolor	1		2			
B. flavistriga		1	2		4	
Stenacron interpunctatum						
Stenonema vicarium		2				1
S. integrum		1	2			
S. terminatum	4	4	2			1
Isonychia sayi			3			
Procloeon sp.						
Trichoptera (Caddisflies)						
Cheumatopsyche spp.	12		10	18	13	12
Hydropsyche betteni	12	31	13	13	9	25
Ceratopsyche bifida	5	1	2	1	1	
C. sparna	3	48	3			
Chimarra obscura	2					
Brachycentrus numerosus	2		6			3
Pseudostenophylax sp.						
Megaloptera (Dobsonflies)						
Corydalus cornutus	1		1			
Odonata (Dragonflies)						
Boyeria spp.			5	4	3	1
Argia apicalis						
Calopteryx spp.						
Coleoptera (Beetles)						
Stenelmis crenata	7			7	21	2
S. humerus	2					
Stenelmis larvae	5	1	4		1	12
Dubiraphia vittata					2	
Dubiraphia larvae						
Optioservus sp.					1	
Macronychus glabratus			1		1	
Psephenus herricki						
Berosus larvae	1					1

**Table 3 (continued)**  
**Rapid Bioassessment Results - Indian Creek Watershed**  
**August 2002**

	Site #					
	1	2	3	4	5	6
	—	—	—	—	—	—
Isopoda (Pillbugs)						
Caecidotea spp.			1			
Gastropoda (Snails)						
Stagnicola caperatum						
Physella gyrina			6		2	1
Fossaria spp.						
Elimia livescens						7
Helisoma spp.					1	1
Lymnaea spp.	1					
Ferrissia spp.			1			
Pelycepodata (Clams)						
Sphaerium spp.					22	3
Pisidium spp.						
Corbicula fluminea						
Turbellaria (Flatworms)						
Hirudinea (Leeches)					5	
Oligochaeta (Worms)						
Tubificidae						
Lumbricidae						
Decapoda (Crayfish)						
Orconectes sp.			1		3	
Total	100	100	100	100	100	100

**Table 3 (cont.).  
Rapid Bioassessment Results - Indian Creek Watershed**

	Site #					
	7	8	9	10	11	12
	<hr/>	<hr/>	<hr/>	<hr/>	<hr/>	<hr/>
Chironomidae (Midges)	7	23	1	16	24	46
Empididae (Danceflies)						
Simuliidae (Blackflies)					1	
Tipulidae (Craneflies)						
Tipula sp.						
Antocha sp.						2
Ephemeroptera (Mayflies)						
Heptagenia sp.					1	
Baetis brunneicolor				2	5	1
B. flavistriga				2	1	6
Stenacron interpunctatum		1		1	4	3
Stenonema vicarium						3
S. integrum					1	1
S. terminatum					5	
Isonychia sayi					1	6
Procloeon sp.						1
Trichoptera (Caddisflies)						
Cheumatopsyche spp.	21			20	12	6
Hydropsyche betteni	7		2	43	14	
Ceratopsyche bifida						1
C. sparna					13	
Chimarra obscura						
Brachycentrus numerosus				6	2	
Pseudostenophylax			1			
Megaloptera (Dobsonflies)						
Corydalus cornutus						
Odonata (Dragonflies)						
Boyeria spp.	4		2			
Ischnura spp.		7				
Calopteryx spp.					1	
Coleoptera (Beetles)						
Stenelmis crenata		20	3	2	6	10
Stenelmis larvae		6	18		6	11
Dubiraphia vittata	1	1		3		1
Dubiraphia larvae	12	1				
Optioservus sp.	1	1				
Macronychus glabratus				1		
Psephenus herricki						
Berosus larvae	1					

**Table 3 (continued)**  
**Rapid Bioassessment Results - Indian Creek Watershed**  
**August 2002**

	Site #					
	7	8	9	10	11	12
	—	—	—	—	—	—
Isopoda (Pillbugs)						
Caecidotea spp.	1	9		2		
Gastropoda (Snails)						
Stagnicola caperatum	36		69			
Physella gyrina	5	15	2			
Fossaria spp.		3				
Elimia livescens						1
Helisoma spp.						
Lymnaea spp.						
Ferrissia spp.					1	
Pelycepodata (Clams)						
Sphaerium spp.			1		1	
Pisidium spp.	1	5				
Corbicula fluminea	1					
Turbellaria (Flatworms)		4				
Hirudinea (Leeches)	1	3				
Oligochaeta (Worms)						
Tubificidae		1				
Lumbricidae	1					
Decapoda (Crayfish)						
Orconectes sp.			1	2	1	1
Total	100	100	100	100	100	100

Table 4. Data Analysis for 8/02 Samples

	METRICS					
	1	2	Site #		5	6
	1	2	3	4	5	6
# of Genera	13	7	17	5	16	12
Biotic Index	5.7	7.1	5.9	6.4	6.2	6.9
Scrapers/Filterers	0.5	0.1	0.4	0.2	0.6	0.6
EPT/Chironomids	1.0	8.8	1.3	0.5	2.7	1.4
% Dominant Taxon	21	49	41	18	22	25
EPT Index	7	4	7	2	4	4
Community Loss Index	0.5	1.1	0.4	1.8	0.4	0.7
% Shredders	0	1	1	0	3	1
SCORING						
	1	2	Site #		5	6
	1	2	3	4	5	6
# of Genera	6	2	6	0	2	6
Biotic Index	6	2	6	4	4	4
Scrapers/Filterers	2	0	0	0	2	2
EPT/Chironomids	6	6	6	6	6	6
% Dominant Taxon	6	0	0	6	4	4
EPT Index	6	2	6	0	2	2
Community Loss Index	4	4	6	2	6	4
% Shredders	3	6	6	3	6	6
TOTAL	39	22	36	21	36	34
% of Reference	85	49	78	46	78	74
Impairment Category	N	M	S	M	S	S
N = NONE      S = SLIGHT      M = MODERATE      Sv = SEVERE						

Table 4 (continued). Data Analysis for Samples

	METRICS					
	7	8	Site #		11	12
	7	8	9	10	11	12
# of Genera	14	13	9	11	16	13
Biotic Index	6.9	7.0	6.6	6.8	5.4	5.6
Scrapers/Filterers	1.4	9.0	31	0.1	0.5	2.2
EPT/Chironomids	4.0	0.1	3.0	4.6	2.5	0.6
% Dominant Taxon	36	26	69	43	14	27
EPT Index	2	1	2	5	9	8
Community Loss Index	0.7	0.6	1.1	0.5	0.3	0.0
% Shredders	0	0	2	2	1	1
	SCORING					
	7	8	Site #		11	12
	7	8	9	10	11	12
# of Genera	6	6	4	4	6	6
Biotic Index	4	2	4	4	6	6
Scrapers/Filterers	6	6	6	0	2	6
EPT/Chironomids	6	0	6	6	6	6
% Dominant Taxon	2	4	0	0	6	4
EPT Index	0	0	0	4	6	6
Community Loss Index	4	4	4	4	6	6
% Shredders	3	3	6	6	6	6
TOTAL	31	25	30	28	44	46
% of Reference	67	54	65	61	96	100
Impairment Category	S	S	S	S	N	N
N = NONE      S = SLIGHT      M = MODERATE      Sv = SEVERE						

## RESULTS AND IDENTIFICATION OF PROBLEM AREAS

Instream chemical parameters measured at each site indicate that dissolved oxygen (D.O.), pH, temperature, and conductivity fell within acceptable ranges for most forms of aquatic life. Abundant algal growth (stimulated by high nutrient inputs) is usually indicated by pH readings significantly higher than 8.0. This was the case at sites 4 (upper Indian Creek) and 8 (Frederick Ditch) during the dry weather sampling. High algal growth rates are also indicated at sites where dissolved oxygen is much higher than the saturation level. This was especially true at site 8 (Frederick Ditch) and 9 (upper Little Indian Creek), where the D.O. level was much higher than saturation during the dry weather sampling. Because algae also use oxygen when light is not present, sites with abundant algae typically have large variations in D.O. During the night or on cloudy days the D.O. at such sites may drop below the 5 mg/l minimum required for healthy aquatic communities.

Nutrient and suspended solids concentrations were relatively low at most sites in Indian Creek, compared to other streams in Indiana flowing through areas with primarily agricultural land uses. A single grab sample from Rans Ditch in the upper Grassy Creek watershed was an exception. The orthophosphorus concentration at this site on October 30, 2002 was 2 mg/l (at least 20 times higher than other sites).

A total of 41 macroinvertebrate genera were collected at the twelve sites. The most commonly collected groups were midge larvae, aquatic beetles, snails, and net-spinning caddisflies. The pollution intolerant groups Ephemeroptera, Plecoptera, and Trichoptera (mayflies, stoneflies, and caddisflies) were abundant at most sites but noticeably absent at sites 8 and 9 in the Little Indian Creek sub-watershed. Many of the sites contained “cool water” forms such as *Brachycentrus numerosus* and *Ceratopsyche sparna*. These species are only found where abundant groundwater contributions keep the water relatively cool in the summer months.

Table 4 shows how the aquatic communities at the eleven study sites compared to that of the reference site. Impacted sites are shown graphically in Figure 9. The site with the highest biotic index and habitat value was on Indian Creek just upstream with its confluence with the Tippecanoe River. This means that Indian Creek is probably not having a negative effect on water quality of the Tippecanoe River. Its habitat and biota are similar to that of a “reference” stream. All upstream sites in the Indian Creek watershed were slightly or moderately impacted. This means that improvements can be made there.

Figure 10 shows the normal relationship of biotic index scores to habitat values (a linear relationship according to [10]). The figure also shows a range of plus or minus 10% to account for a certain amount of measurement variability. When biotic index values fall outside this range, the site typically has degraded water quality. Fig.10 indicates that seven of the eleven study sites had biotic values outside the range expected from their measured habitat value. Therefore, these sites are impacted by both water quality and habitat degradation. The largest deviation from the expected value occurred at sites 4 and 10. Efforts to improve water quality in the watershed

should be focused on these areas (Fig. 11) in the upper Grassy Creek and upper Indian Creek sub-watersheds.

In contrast, the biotic index of some streams will not improve until aquatic habitat is improved. These areas are shown in Fig. 12. Habitat improvements include establishing shading trees, decreased channelization, and streambank stabilization.

Figure 9.  
Degrees of Impairment in the Indian Creek Watershed  
Yellow = Moderate Impairment  
Blue = Slight Impairment  
Green = No Impairment

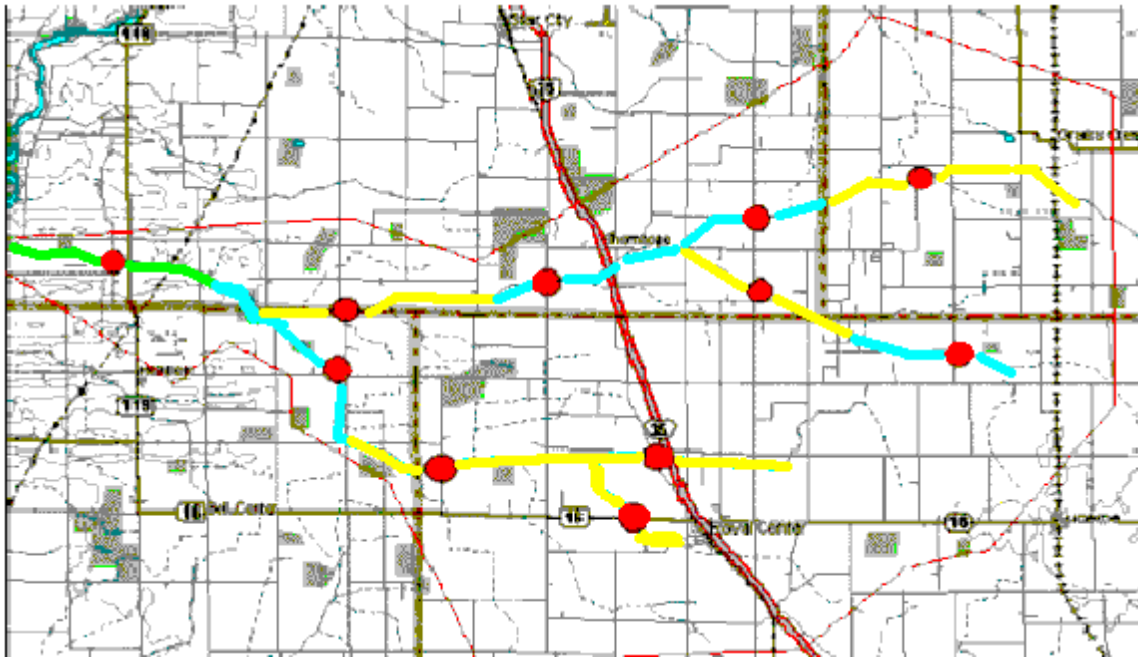


Figure 10.

The normal relationship between habitat and biotic index score is shown below.  
Sites falling outside the normal relationship (plus or minus 10%)  
are probably affected by degraded water quality.

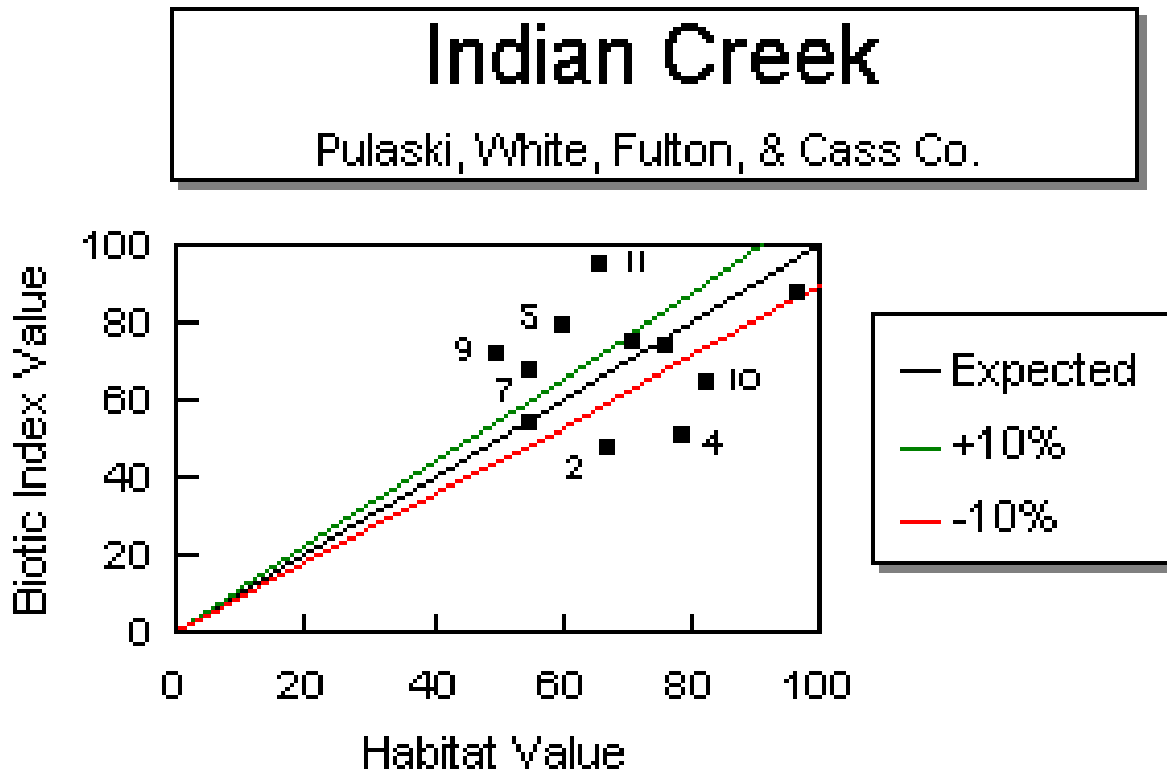


Fig.11. Sub-watersheds with highest potential for water quality improvement and with highest priority for BMPs (highlighted in green)

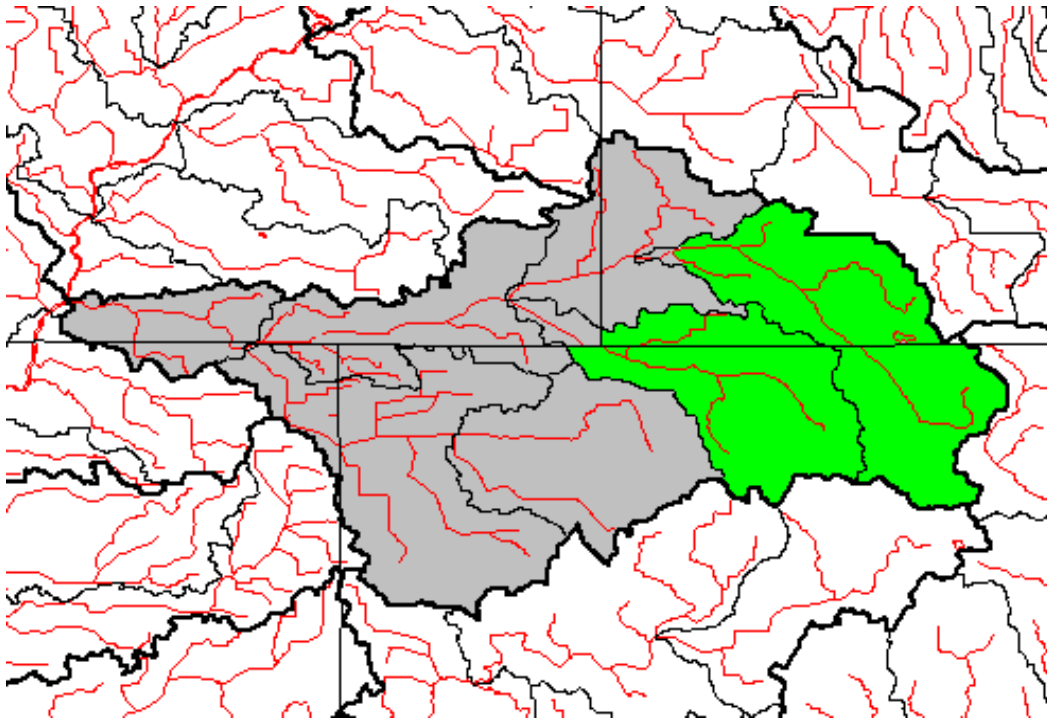
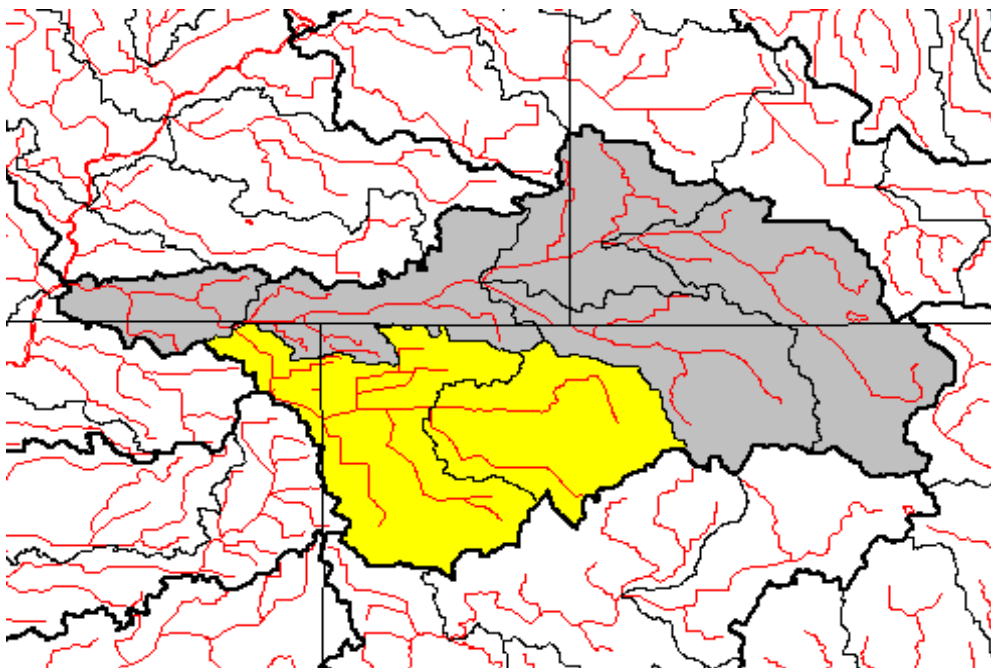


Fig. 12. Sub-watersheds impaired most by habitat degradation and which need riparian vegetation and channel restoration (highlighted in yellow)



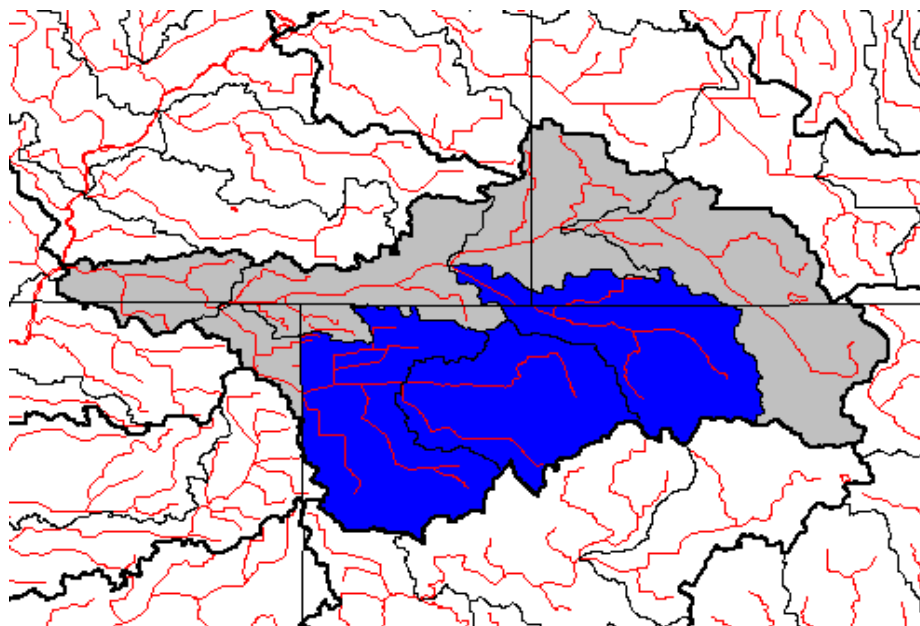
What kinds of water quality problems are contributing to impairment? Table 5 shows sediment-tolerance values for many of the commonly collected animals in these streams. The proportion of sediment and turbidity-intolerant forms was significantly higher at the reference site than sites 4, 5, 7, 8, and 9. These results indicate that sediment-related impairment may be contributing to the water quality problems in the Indian Creek watershed, especially in the upper Indian Creek and Little Indian Creek sub-watersheds.

Table 5. Sediment-Intolerant Species Observed

% of Sediment-Intolerant Organisms at the Reference		11%
% of Sediment-Intolerant Organisms at the Study Sites		
	Site 1	12%
Sediment Intolerant Organisms	Site 2	50%
Ceratopsyche spp.	Site 3	12%
Chimarra obscura	Site 4	1%
Brachycentrus numerosus	Site 5	1%
Pseudostenophylax spp.	Site 6	4%
Stenonema vicarium	Site 7	0%
Stenonema terminatum	Site 8	0%
Isonychia sayi	Site 9	1%
	Site 10	6%
	Site 11	21%

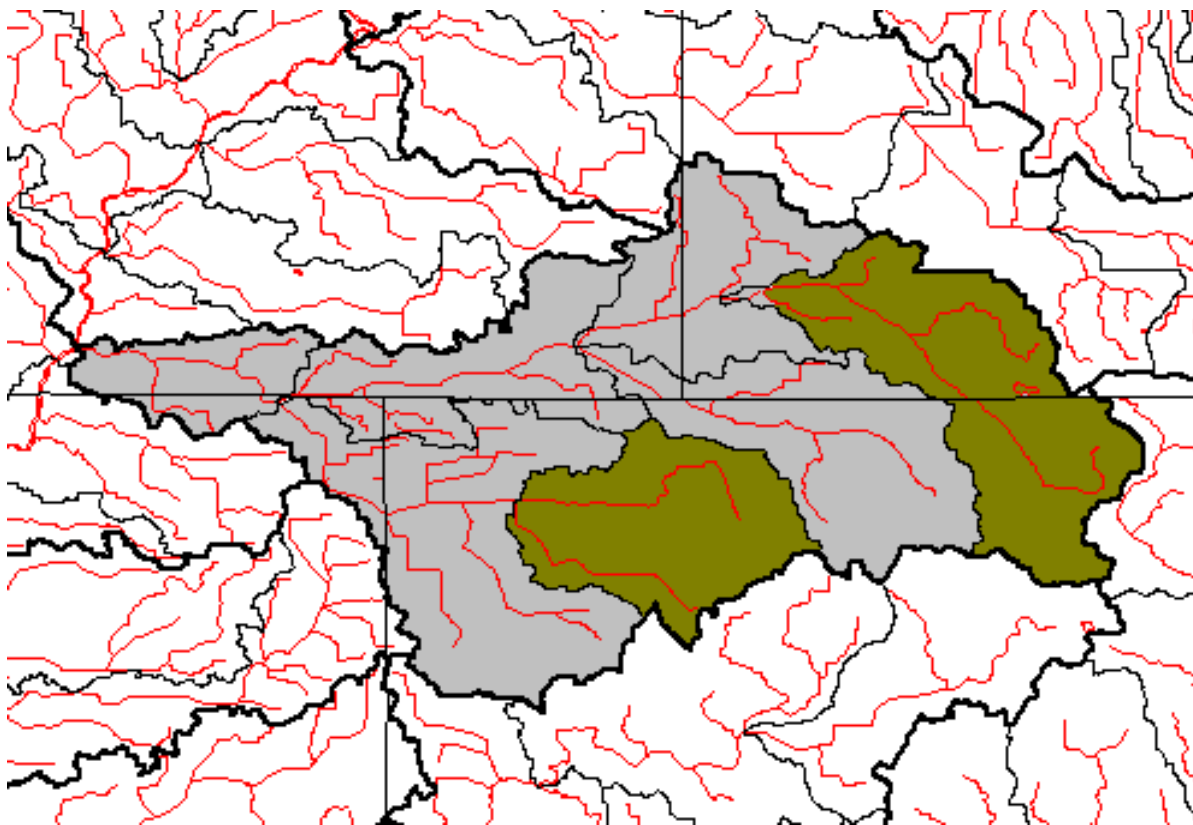
Best management practices which reduce soil erosion and increase streambank stability should be used in the sub-watersheds shown in Fig. 13.

Fig. 13. Sub-watersheds affected by sediment (need BMPs for sediment reduction) are highlighted in blue.



When the number of animals which eat algae attached to rocks (“scraper” organisms) become numerically dominant, excessive nutrient inputs are often the cause. Scrapers dominated at sites 7 and 9 in upper Little Indian Creek. The upper Grassy Creek sub-watershed is an interesting example of a stream with a biotic index much higher than its habitat value. According to [10], this type of effect also occurs where nutrient inputs are excessive. Best management practices to reduce nutrient inputs should be employed in these areas, shown in Fig. 14. Some nutrient BMPs, such as proper manure storage and land application, may also bring down the high concentrations of E.coli found in Grassy Creek..

Fig. 14. Sub-watersheds affected by excessive nutrient inputs and need nutrient BMPs (highlighted in brown)



“Scraper Organisms”

Heptagenia spp.  
Stenacron spp.  
Stenonema spp.  
Stenelmis spp.  
Dubiraphia spp.  
Optioservus spp.  
Macronychus glabratus

Psephenus herricki  
Physella gyrina  
Elimia livescens  
Ferrissia spp.  
Helisoma spp.  
Stagnicola spp.  
Lymnaea spp.

## D.. NUTRIENT LOADING PREDICTIONS BASED ON MODELING

Computer models are sometimes useful for helping water resource managers visualize water quality and biological changes that could occur when changes in land use are made. U.S. EPA has recently released a new computer model called AQUATOX.[9] that combines water chemistry with aquatic ecology. The model allows a user to set up a model ecosystem (e.g. a stream with a given depth, length, flow, climate, and water chemistry) and observe how that ecosystem's chemistry and biology changes over time. The model also allows the user to change the ecosystem by increasing or decreasing the amount of pollutant loading that occurs. For example, the user could tell the model that Best Management Practices for agricultural land uses are going to be implemented in a watershed and that phosphorus, nitrogen, and suspended solids concentrations are going to be cut in half by these BMPs. AQUATOX tells the user how BMP implementation would affect the chemistry and biology of a stream in that watershed.

The AQUATOX model was used to predict changes in the Indian Creek watershed that could occur with BMP implementation. The model used the following assumptions, based on actual measurements in Indian Creek made as part of this study:

### Physical Parameters

Reach Length	40 km
Mean Depth	0.4 m
Surface Area	100,000 sq. m
Temperature Range	0 - 28 degrees C
Light	361 Ly/d
Latitude	41 degrees N

### Initial Chemistry (average values presently observed in the watershed)

Ammonia	0.05 mg/l
Nitrate	2 mg/l
Phosphate	0.1 mg/l
Oxygen	12 mg/l
TSS	5 mg/l

To measure the changes expected to occur with BMP implementation, a 50% reduction in nutrients and sediment (a reasonable goal for the watershed) was plugged into the model. The changes which could occur with BMP implementation are shown in Figures 15 -17 and listed in tabular form in Appendix A. The model predicts that nutrient values will decrease significantly, especially during spring and autumn. Physical and biological improvements associated with BMP implementation include an increase in water clarity and an increase in benthic biomass, especially in clean water forms such as mayflies and caddisflies.

Fig. 15. Reductions in nutrients during one year

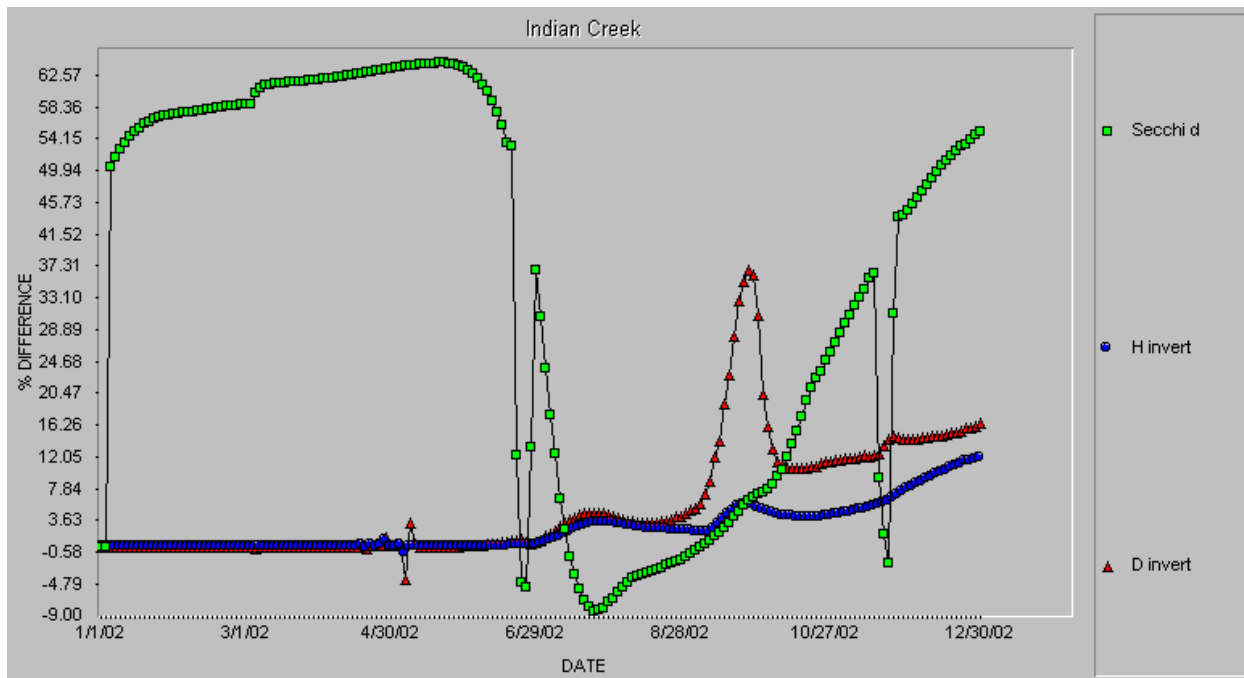
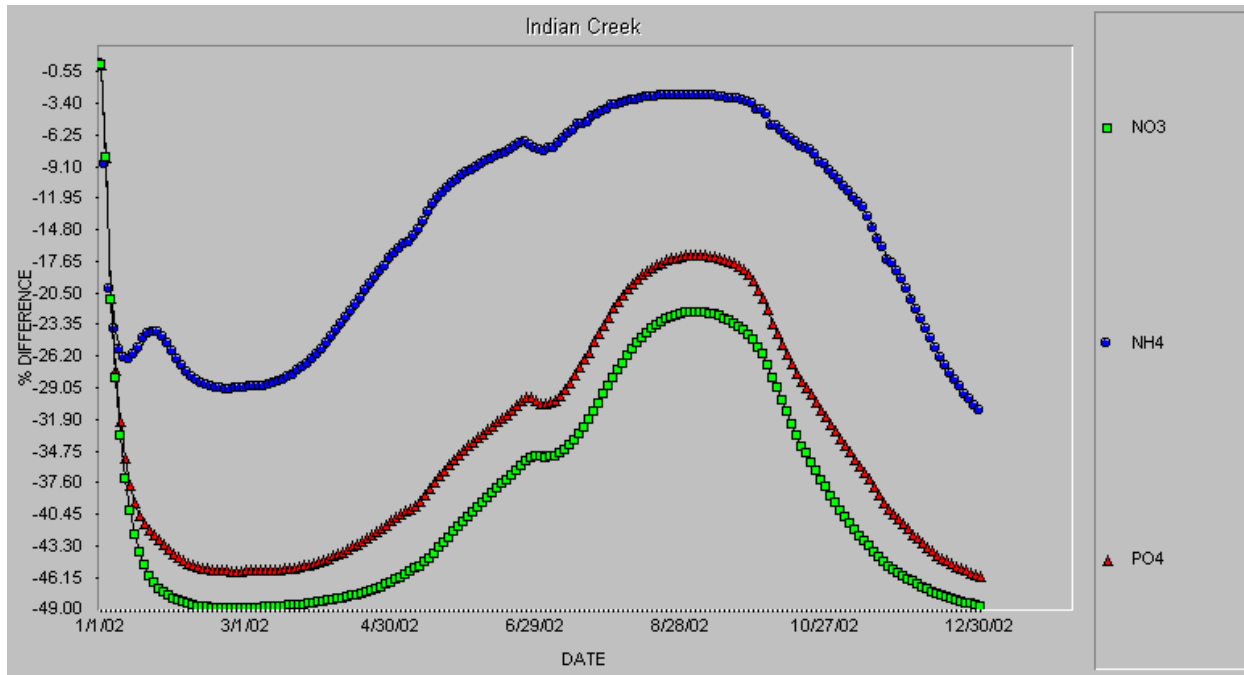
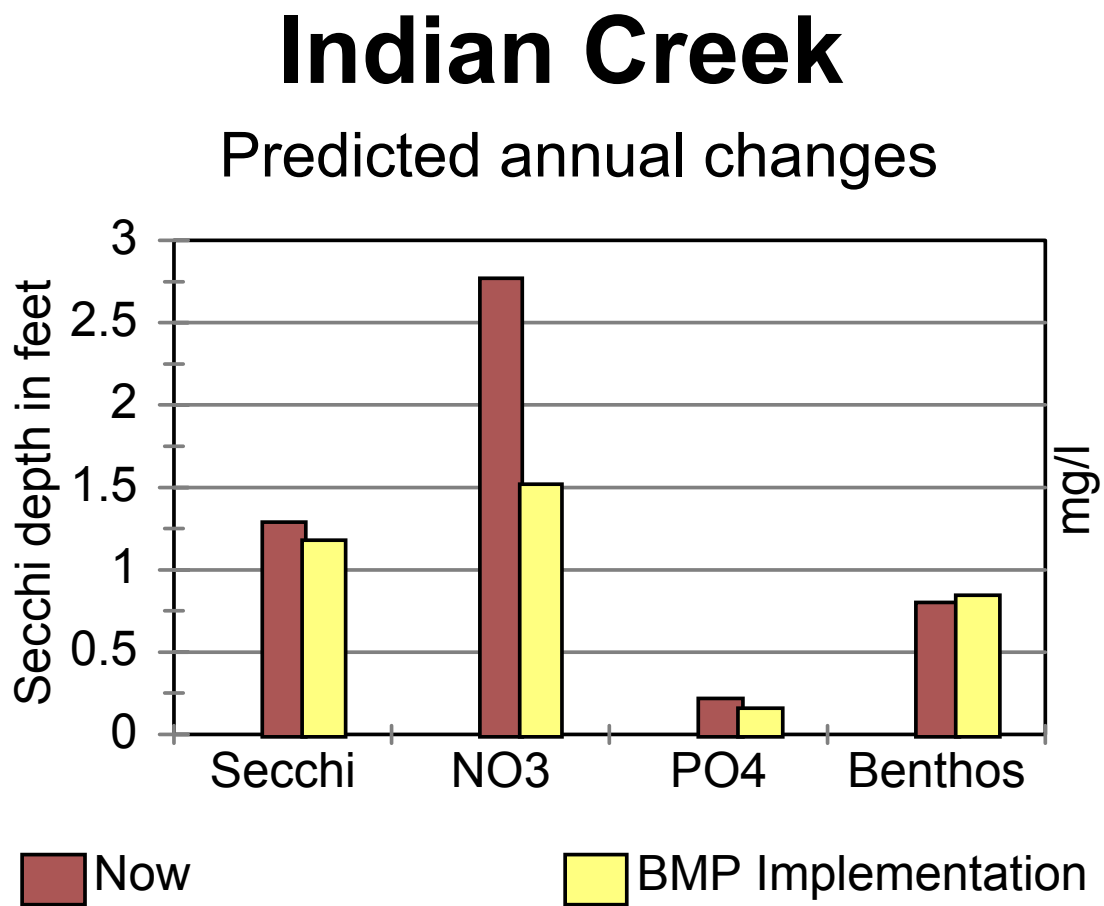


Fig. 16 Predicted changes in transparency (Secchi d) and benthos over 1 year.  
H invert = herbivorous invertebrates. D invert = detritivorous invertebrates.

Fig. 17 Predicted changes in transparency, nutrients, and biology with BMP implementation. The results are averages for one year.



#### IV. SUMMARY OF PROBLEMS

	<b><u>Problems</u></b>	<b><u>Priority</u></b>
Upper Grassy Creek	Nutrients	High
Upper Indian Creek	Sediments	High
Upper Little Indian Creek	Degraded Habitat Nutrients	Low Medium

#### V. PROPOSED SOLUTIONS

This plan proposes to reduce nutrient loading in the Indian Creek watershed by 50% and to decrease sedimentation by 10%. The Cass County SWCD has already initiated 47 conservation-related projects in the watershed. Filterstrips and grassed waterways are the primary “best management practices” (BMPs) employed. Total government investment for BMPs in the Cass County portion of Indian Creek is over \$900,000 to date (\$200,000 for installation costs and \$700,000 for conservation easements).

Water quality in the Indian Creek watershed would improve even more if additional implementation of BMPs was carried out. According to the priority summary in Section IV, these should be targeted especially for water quality problems in the upper Grassy Creek and upper Indian Creek watersheds in Fulton and Cass Counties. BMPs that are most effective for nutrient reductions are needed for upper Grassy Creek (and to a lesser extent in Little Indian Creek), while BMPs effective for sediment reductions are needed for upper Indian Creek.

Table 6. Summary of Proposed BMPs

	<b><u>Location</u></b>
Nutrient Reduction BMPs	Upper Grassy Creek
Manure Storage	Little Indian Creek
Manure Testing and Land Application	
Soil Testing and Nutrient Management	
Sediment Reduction BMPs	Upper Indian Creek
Grade Control Structures	
WASCOBs	
Streambank Stabilization	
Both Nutrient and Sediment BMPs	All Three Sub-Watersheds
Filter Strips	
Grassed Waterways	
Contour Buffer Strips	
Livestock Exclusion	
Constructed Wetlands	

Fig. 18 shows the location of Rans Ditch in the Upper Grassy Creek watershed. This would be an excellent site for a constructed wetland. A constructed wetland could help control high phosphorus loading (2 mg/l) observed in a grab sample collected from the stream on October 30, 2002.

Fig. 18. Potential site for a constructed wetland

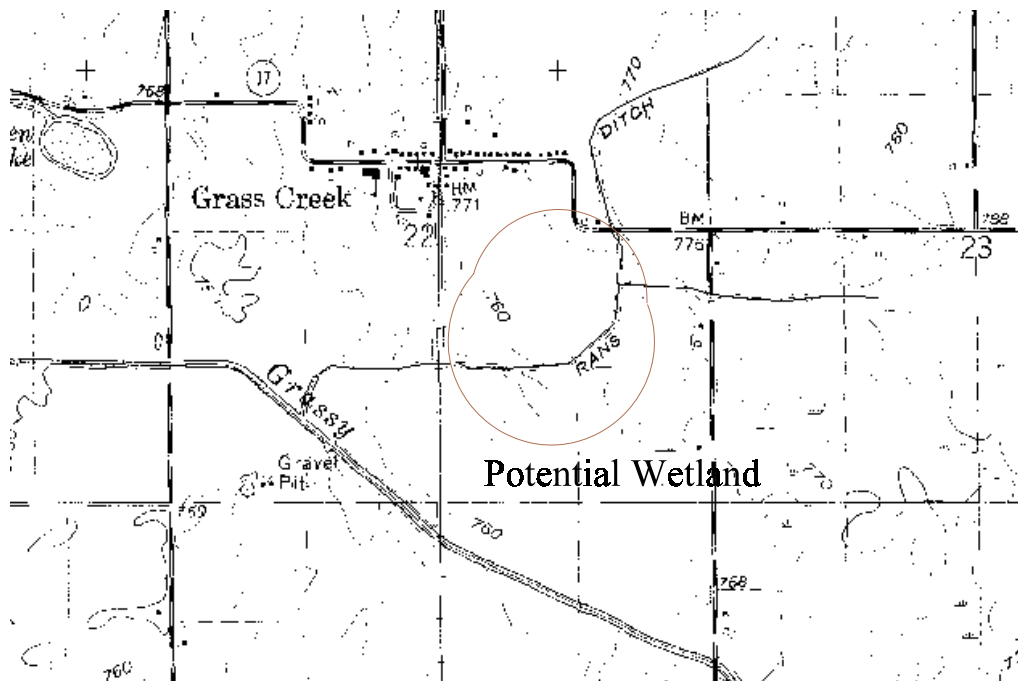


Fig. 6 shows the locations of several sites in the watershed where streams flow through areas with steep slopes and erodible soils. Photographs of some of these sites are shown in Fig. 19 and their locations are given more precisely in Table 7. These areas should be targeted for erosion-control BMPs.

Table 7. Potential sites for erosion-control BMPs

<b><u>Waterbody</u></b>	<b><u>County</u></b>	<b><u>Township</u></b>	<b><u>Section</u></b>
Walsh Ditch	Fulton	Wayne	20
Unnamed Stream	Cass	Harrison	9
Indian Creek	Cass	Harrison	11
Little Indian Cr.	Cass	Harrison	17

One site on Indian Creek as it flows along the Pulaski/White County line needs a riparian buffer and bank stabilization to keep bank erosion from harming the stream and to keep the stream from wearing away the county road that parallels it for almost a mile. A photo of this site is shown in Fig. 19. Bioengineering techniques would work well here.

There are several sites in the watershed where livestock (especially cattle) have direct access to streams. Livestock wear down the adjacent banks and destroy riparian vegetation as they go to the stream for water. An example of one site is shown in a photo in Fig. 19. Livestock exclusion fences could be used in these areas.

Fig. 19.  
Potential BMP Sites in the Indian Creek Watershed

L. Indian Cr. - White(Cass) - Sec 2  
Livestock access



Indian Cr. - White/Pulaski Line  
Riparian buffer



Walsh Ditch - Fulton(Wayne) - Sec 20  
Erodible soil - high slope



Unnamed Trib. - Cass(Harrison) - Sec 9  
Erodible soil - high slope



Indian Cr. - Cass(Harrison) - Sec 11  
Erodible soil - high slope



L. Indian Cr. - Cass(Harrison) - Sec 17  
Erodible soil - high slope



Wetland restorations or enhancements would improve water quality where willing landowners would cooperate. These are especially valuable where wetlands are present immediately adjacent to a stream. Areas where such sites occur in the watershed are shown in Table 8.

Table 8. Potential sites for wetland restorations

<b><u>Waterbody</u></b>	<b><u>County</u></b>	<b><u>Township</u></b>	<b><u>Section</u></b>
Unnamed trib.	Cass	Harrison	15
Indian Creek	Cass	Harrison	4
Little Indian Cr.	Cass	Boone	16
Little Indian Cr.	White	Cass	2
Bonnell Ditch	Pulaski	Indian Cr	36
Costello Ditch	Fulton	Wayne	25
Shanley Ditch	Pulaski	Van Buren	13
Strubhar Ditch	Cass	Boone	21

Because of the large number of confined feeding operations in the watershed, many tons of manure are generated. Best management practices for manure handling should be vigorously pursued. Grants for manure management are available and are discussed in more detail in Section VII.

Some farmers in the watershed are exploring the possibility of having the watershed declared a “legal drain” so that channel maintenance (especially log jam removal and sediment dredging) can be done on a regular basis. Presently, this type of activity is done sporadically by individual landowners at their own expense. If done without regard to best management practices, channelization can wreak havoc on the biological community of a stream. For maintaining and enhancing the quality of streams in the Indian Creek watershed, it is important that the following minimum guidelines be applied:

Where tree removal is necessary for equipment access, cut only on one side. This leaves one side with a row of trees to provide shade, to help keep the water cool, and to provide a source of food for stream life.

Do channel maintenance in small chunks. This allows other areas to recover and minimizes the damage in the watershed.

Don’t dig streams out to a uniform depth. Keep shallow, swift-running areas (riffles) present. These are important places for aquatic life to grow.

## VI. PRELIMINARY COST ESTIMATES OF ELEMENTS OF THE PLAN

### BEST MANAGEMENT PRACTICES FOR LAND TREATMENT

The following costs are estimates based on recent expenditures by the Cass County SWCD, those listed by the Noble County SWCD [11] in 1982 (doubled to provide up-to-date estimates), estimates from [12], and recent LARE grants.

Filter strip	\$200 per acre + rental
Grassed waterway	\$5000 per acre + rental
WASCOB	\$2000
Streambank vegetation	\$10 per linear foot
Sediment Trap	\$3 per cubic yard
Terraces	\$10 per linear foot
Grade stabilization structure	\$7000
Livestock exclusion	\$1 per linear foot
Conservation easement	\$1350 per acre for 10 year rental
Constructed wetland	\$50,000 per acre
Streambank bioengineering	\$ 50 per linear foot

The Indiana Department of Environmental Management, Office of Water, Watershed Branch uses a spreadsheet to predict loading reductions associated with various BMP practices [27]. Their spreadsheet model predicts the following loading in an agricultural watershed of this size before BMP implementation:

Suspended Sediment	11,000,000 pounds per year
Total Nitrogen	170,000 pounds per year
Total Phosphorus	13,000 pounds per year

The model also uses various published data sources to predict load reductions associated with BMPs. For example, the model predicts an average nutrient and sediment reduction of 40-70% when vegetative filter strips are installed. Using this information and the cost estimates shown above, the following costs and load reductions for BMP implementation can be predicted:

<b><u>Practice</u></b>	<b><u>Cost</u></b>
Land Treatments	
50 Filter Strips	\$40,000
10 Grassed waterways	\$50,000
5 WASCOBs	\$10,000
Wetland Restorations (5 sites)	\$ 5,000
Livestock Exclusion (3 sites)	\$ 5,000
Constructed wetland (1 site)	\$50,000
Covered manure facility (3 sites)	\$30,000
Streambank stabilization	
bioengineering (1000 feet)	\$40,000
Streambank vegetation (5000 feet)	\$50,000
TOTAL	\$280,000

	<b><u>Sediment</u></b> <b><u>Lb/yr</u></b>	<b><u>Nutrients</u></b> <b><u>Lb/yr</u></b>
PREDICTED LOAD REDUCTION	8 x 10 <sup>6</sup>	75,000

## VII. PROJECT CONSTRAINTS AND REMEDIES

As with most environmental restoration projects on public and private land, there are constraints which could keep the plan from being implemented. Some of the major potential constraints are listed in Table 9.

Table 9. Potential Project Constraints and Remedies

<b><u>Proposed Action</u></b>	<b><u>Potential Constraints</u></b>	<b><u>Potential Remedies</u></b>
Land Treatments	Costs to landowners	Cost-share / Grants
Livestock Fencing	Costs to landowners	Cost-share / Grants
Constructed Wetland	Costs to landowners	Cost-share / Grants
Habitat Improvement	Extra drainage costs	None presently available
Manure Management	Costs to landowners	Cost-share / Grants

Because so many remedies rely on cost sharing and grants to defray the costs to local landowners, some of the potential grants available to fund implementation of this project are shown below:

LARE Program	Nonpoint source planning, implementation (Ag BMPs)
319 Program	Nonpoint source planning, implementation (Ag BMPs)
Ducks Unlimited	Wetland restoration and construction
Department of Interior	Wetlands conservation grants
Pioneer Hi-bred Intl.	Agricultural environmental grants
USDA	Sustainable Agriculture Research and Education
U.S. Fish & Wildlife	North American Wetlands Conservation Act
U.S. EPA	Five-star restoration challenge grants
NIPSCO	Environmental challenge fund grants
National Fish & Wildlife Foundation	"Bring back the natives" watershed restoration
IDEM	Water quality improvement grant program
Office of Land Quality	
Indiana Rural Community Assistance Fund	Nonpoint source planning and construction

There are institutions already in place to help carry out the plan. The local SWCDs and associated federal, state, and local professionals in the FDA Service Center offices are already at work on many of these types of projects. Names, phone numbers, and addresses of other water quality related groups active in the watershed are shown below:

<b><u>Name</u></b>	<b><u>Phone</u></b>	<b><u>Address</u></b>	<b><u>Assistance</u></b>
John Peverly Purdue University CES Upper Tippecanoe HUA	765-494-6134	1150 Lilly Hall Purdue University W. Lafayette, IN 47907	Technical Education
Chad Watts Nature Conservancy Tippecanoe River Project	219-946-7491	103 N. Market St. Ste. 102 Winamac IN 46996	Cost share

## VIII. PUBLIC PARTICIPATION

A public meeting was held December 3, 2002 at Pioneer High School in Royal Center. Forty-five people attended (see participant list in Appendix C). A flier explaining the purpose of the project and its results was prepared and passed out to each person attending the opening meeting (a copy is included in Appendix D). There was a question and answer period. There was also a short presentation by the Nature Conservancy on the availability of matching funds for land treatments in the watershed. Many meeting participants were watershed farmers who expressed interest in having Indian Creek declared a “legal drain” to facilitate channel maintenance work. Environmentally sensitive ways to do this were discussed.

## IX. REFERENCES

1. Hoggatt, R.E. 1975. Drainage areas of Indiana streams. U.S. Geological Survey, Water Resources Division, Indianapolis, IN.
2. Arvin, D.V. 1989. Statistical summary of streamflow data for Indiana. U.S. Geological Survey Open-file Report 89-62, Indianapolis, IN.
3. Homoya, M.A., D.B. Abrell, J.R. Aldrich, and T.W. Post, 1985. The natural regions of Indiana. *Proc. Ind. Acad. Sci.* 94: 245-268.
4. Whitaker, J.O. and J.R. Gammon, 1988. Endangered and threatened vertebrate animals of Indiana: their distribution and abundance. *Ind. Acad. Sci. Monograph Number 5.* Indianapolis, IN.
5. Carney, D.A., L.M. Page, and T.M. Keevin, 1993. Fishes of the Tippecanoe River, Indiana: and outstanding midwestern stream. *Proc. Ind. Acad. Sci.* 101: 201-219.
6. Cummings, K.S., C.A. Mayer, L.M. Page, and J.M.K. Berlocher, 1987. Survey of the freshwater mussels of the Wabash River drainage. Phase 1: Lower Wabash and Tippecanoe Rivers. *Illinois Natural History Survey Technical Report 1987 (5).* Champaign, IL.
7. Bright, G.R., 1998. Rapid bioassessment of the Twelve Mile Creek watershed using macroinvertebrates. A LARE-funded study presented to the Cass County SWCD, Logansport, IN.
8. Gammon, J.R. and C.W. Gammon, 1993. Changes in the fish community of the Eel River resulting from agriculture. *Proc. Ind. Acad. Sci.* 102: 67-82.
9. U.S. EPA, 2000. AQUATOX: a modular fate and effects model for aquatic ecosystems. Office of Water, Washington, D.C. EPA-823-R-00-006.
10. U.S. EPA, 1989. Rapid bioassessment protocols for use in streams and rivers. EPA/444/4-89-001. Office of Water, Washington, D.C.
11. Noble County SWCD, 1982. Impact of land treatment on the restoration of Skinner Lake, Noble County, Indiana. Indiana Department of Natural Resources, Division of Soil Conservation, Indianapolis IN. 28 pp.
12. IDEM, 1986. Indiana lake classification system and management plan. Office of Water Management, Indianapolis, IN. 112 pp.
13. USDA, 1981. Soil survey of Cass County, Indiana. Soil Conservation Service (Natural Resource Conservation Service), Indianapolis IN.

14. USDA, 1987. Soil survey of Fulton County, Indiana. Soil Conservation Service (Natural Resource Conservation Service), Indianapolis IN.
15. USDA, 1982. Soil survey of White County, Indiana. Soil Conservation Service (Natural Resource Conservation Service), Indianapolis IN.
16. USDA, 1968. Soil survey of Pulaski County, Indiana. Soil Conservation Service (Natural Resource Conservation Service), Indianapolis IN.
17. USDA, 2000. Cropland data layer for Indiana. National Agricultural Statistics Service. Data available on the internet at [www.usda.gov/nass](http://www.usda.gov/nass).
18. Simon, T.F. and R. Dufour, 1998. Development of biotic integrity expectations for the ecoregions of Indiana. V. Eastern corn belt plain. U.S. EPA Region V, Watershed and Non-point Source Branch. Chicago, IL. EPA 905/R-96/002.
19. Indiana University School of Environmental and Public Affairs, 2002. Unpublished limnological data for Fletcher Lake. Available from William Jones, Indiana University, Bloomington, IN.
20. Indiana Geological Survey, 1995. Atlas of hydrogeologic terrains and settings of Indiana. Open file report to the Indiana State Chemist. Bloomington, IN.
21. IDEM, 2001. Unified watershed assessment: 2000-2001. Office of Water, Watershed Management Branch, Indianapolis, IN.
22. Indiana Natural Resources Commission, 1993. Outstanding rivers list for Indiana. Indiana Register. March 1, 1993. Vol 16, Number 6, pp 1677-1680.
23. U.S. EPA, 2002. Unpublished data for Royal Center Wastewater Treatment Plant. Available on the internet at [www.epa.gov/enviro](http://www.epa.gov/enviro).
24. IDNR, 2002. Hoosier Riverwatch data for Indiana. Available on the internet at [www.in.gov/dnr/soilcons/riverwatch](http://www.in.gov/dnr/soilcons/riverwatch).
25. U.S. EPA, 2002. Index of watershed indicators. Available on the internet at [www.epa.gov/iwi](http://www.epa.gov/iwi).
26. IDEM, 2002. Unpublished list of confined feeding operations for Indiana. Available from the Office of Land Management, Indianapolis, IN.
27. IDEM, 2002. BMP load reductions for use in nonpoint source pollution control projects. Office of Water, Watershed Branch. Indianapolis, IN

**Appendix B.  
Habitat Scoring Results**

	Site Number											
	1	2	3	4	5	6	7	8	9	10	11	12
	—	—	—	—	—	—	—	—	—	—	—	—
<b>SUBSTRATE</b>	12	8	10	10	8	10	8	8	8	10	8	14
<b>COVER</b>	9	8	6	10	6	6	2	2	3	10	8	11
<b>CHANNEL</b>	12	5	6	9	8	8	5	5	6	9	7	14
<b>RIPARIAN</b>	9	6	7	6	5	7	6	6	6	8	6	12
<b>POOL/RIFFLE</b>	14	10	9	11	7	11	5	4	4	11	10	10
<b>GRADIENT</b>	6	6	6	6	6	6	6	6	6	6	6	6
<b>DRAINAGE AREA</b>	11	10	10	8	7	9	8	5	6	8	8	10
<b>TOTAL</b>	73	53	54	60	47	57	40	36	39	62	53	77